AN EMPIRICAL STUDY OF FUTURE CHANGES IN THE EUROPEAN CAR INDUSTRY

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Glossary

Abbreviation	Description
ABS	Anti-blocking system
ASC	Anti-skid system
ATZ	Automobiltechnische Zeitung (Technical Automotive Newspaper)
BPR	Business Process Reengineering
CAN	Central Area Network
CKD	Completely knocked down
DFL	Drive For Leadership
ESI	Early Supplier Involvement
FBU	Fully built up
FHI	Frauenhofer Institute for Work Process and Organisation
GATT	General Agreement for trade and Tariffs
GDI	Gross domestic income
GDP	Gross domestic product
ICOSS	Inter Co-Operational Supplier Structure
IMVP	International Motor Vehicle Program
JIT	Just in time
KVP	Kontinuierlicher Verbesserungs Prozess (Continuous Optimisation Process)
MIT	Massachusetts Institute of Technology
MITI	Ministry of International Trade and Industry
n.i.	No information
OEM	Original equipment manufacturer
PICOS	Purchased Input Concept Optimisation with Supplier
POZ	Prozess Optimierung Lieferanten (Process Optimisation Supplier)
QFD	Quality Functional Deployment
R & D	Research and development
RAM	Random Access Memory
ROM	Read Only Memory
SAS	Society of Automotive Engineers
SE	Simultaneous Engineering
SKD	Semi-knocked down
SOP	Start of production
TQM	Total Quality Management
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
VIA NRW	Verbundinitiative Automobil Northein-Westfalen (Co-ordinated Automobile Initiative of North Rhine-Westphalia)
w.A.	Without Author
ZfbF	Zeitschrift für betriebswirtschaftliche Forschung (Journal of Business Research)

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Abstract

The automotive supplier industry and the relationship between car manufacturers and suppliers has been confronted with major changes resulting from OEMs' strategy of stronger product integration and the building of so-called systems, sub-systems and components and segmentation of the supplier industry . Former valid work processes, division of work, organisational structures and also, the general manufacturer-supplier relationship has been subject to intensive evaluation and appropriate adaptation to the changed circumstances.

This research project aims to investigate these changes in the European car industry in greater detail, particularly:

(i) The OEMs' system-building strategy

(ii) What requirements OEMs must meet at the individual supplier levels (system, sub-system, component) and

(iii) The main factors involved in the development of a more efficient relationship between OEMs and suppliers.

To achieve this object, various activities were undertaken including the collecting of information from previous studies, preparing standardised questionnaires and performing investigations within the European car industry and also at a major automotive supplier. The work is based on empirical investigations and personal interviews conducted with key persons in automobile companies and automotive suppliers with the aim of painting a picture of the future situation and developing a proposal based on the information compiled. Finding answers to the above-mentioned issues may be very important and useful in determining internal organisational structure and resource allocation and in making strategic decisions in respect of alliances and collaborations when preparing one's own business for the even fiercer competition that will face automobile suppliers in the future.

Chapter One: Introduction and statement of grounds for the thesis

The rise of and continued success of the Japanese motor industry in the 1980s and 1990s was remarkable[1]. This dominance could be traced to investors' assumptions and speculations until the Massachusetts Institute of Technology (MIT) started its 5-year, 5 million dollar joint international motor vehicle research programme (IMVP) involving numerous internationally renowned institutes and universities. The results[2] of the research revealed clearly the advantages the Japanese had and the reasons for their unmatched success. The Japanese motor industry's well-established "lean philosophy" was pinpointed as the key factor. Startled by these findings, American and Western European automobile companies finally woke up from their lethargy and began trying to revitalise their traditional working procedures. However, their disadvantage in terms of competition, which has become very apparent in the meantime, and the potential risk of losing an even greater market share was further aggravated by Japanese manufacturers' intensified globalisation efforts. Industrialists had become familiar with these particularly due to so-called transplants and the unbalanced export-import agreements between the USA, Europe and Japan. The US motor industry and that of Western Europe both attempted to improve the situation by simply copying[3] the already existing, published and glorified method described in the MIT study and by, at the same time, introducing newly developed tools[4] and processes based upon their respective organisations and social and cultural environments.

Managers were encouraged to accelerate company restructuring and reorganising so as to maintain a competitive position in the market. Structural reforms involving self-image, management and the procurement structure within American and European automobile companies formed the prerequisite for this development.

[1] See Lamming, R., Die Zukunft der Zulieferer, Campus publishing, Frankfurt, New York, 1994, p. 62

[2] See Womack, J.P/ Jones, D.T./Roos, D., The Machine That Changed The World, Rawson Associates, 1990; Krafcik, J.F., Triumph of the Lean Production System, in: Sloan Management Review, Fall 1988, pp. 41-51

[3] see Burt, D./Doyle, M., American Keiretsu: The new weapon to reduce costs.The fact that the successful Japanese methods were adapted to the carmakers' specific cultural, religious, social and geographic structure and situation is one that is often overlooked. Accordingly, due to the differences between the triad markets - Japan, US, Europe - in these points, simply copying the Japanese methods has not been the right approach for winning back lost market share.

[4] In her article: Methode, nicht Mode, in: Manager Magazin, Dec. 1996, pp. 170-176, Shapiro, E.C criticised fashion and the real value of the new upcoming methods and management tools. Companies shouldn't make the mistake of following each trend. In many cases, the only thing distinguishing a new tool is its name. She pointed out that managers prefer to take proclaimed paths on account of the tremendous increase in the pressure to compete and succeed and the fear of missing out on something that other companies are doing.

While internal procedures and structures[5] were being adapted to the new conditions in the first phase, the companies turned to improving the overall value-added chain in the second phase. In their investigations, CLARK and FUJIMOTO reached the conclusion that companies with potent internal and external integration of performance achieved significantly better results in terms of Total Product Quality (TPQ) compared to those who used conservative approaches. The studies showed that Japanese companies had developed organisational structures and processes enabling shorter throughput times and promoting more efficient engineering, which in turn resulted in more environmentally friendly and targeted use of resources and, in the end, in reduced costs. Beyond that, a few Japanese firms went one step further in the attempt to integrate by already incorporating the final customer in the design process[6].

US and European carmakers tried to make use of initial obvious potential by attempting to achieve improved interlocking of the mutually influencing and interdependent tasks and activities among carmakers and suppliers[7]. This approach was pursued further in an attempt to improve integration and utilisation of the suppliers' know-how and competencies already present, with the aim of meeting the demands of intensifying international replacement competition and, as a result, of legal market requirements in respect of

- shorter production life cycles and development periods
- increasing globalisation
- rising pressure from costs
- shorter innovation periods
- more stringent requirements in terms of quality and the environment augmented by enormous pressure from costs[8].

Accordingly, in the German motor industry, suppliers' share in the value-creation chain is between 50% and 60%, for example, and is expected to increase to

[5] See Freiling C./Kils A., Organisation 2000, Gabler publishing, 1994, pp. 64-72, Description about the change from functional organisation to matrix organisation; Zirger, B.J./Maidique, M.A., A Model of new product development: An empirical test, in: Management Science, Vol. 36, No. 7, July 1990, pp. 867-881; Lloyd A.R./Dale B.G./Burnes B., A study of Nissan Motor Manufacturing (UK) Supplier Development Team activities, in Journal of Automobile Engineering, ImechE 1994, pp. 63-68; Clark, K.B./Fujimoto, T., The Power of Product Integrity, in: Harvard Business Review, Nov/Dec. 1990, pp. 107-116

[6] See Clark, K.B./Fujimoto, T., Automobilentwicklung mit System: Strategie, Organisation and Management in Europa, Japan and USA, Campus publishing, 1991, pp. 263-265

[7] See Eversheim, W.(editor), Prozeßorientierte Unternehmensorganisation, 2nd edition, Springer publishing, Berlin, Heidelberg, pp. 121-123

[8] Lopez A. (former member of VW's board, responsible for production and purchasing) stated that one shouldn't hesitate to divide body assembly up between the automobile manufacturer and the supplier, even though this was considered off-limits in the past, Alles vom Zulieferer, in: Automobil-Industrie, May 1996, p. 20.

approx. 70% in the long-term. This parameter is already more than 70% in the Japanese motor industry. Areas in the OEMs that used to be considered taboo have also been discussed in the course of the aforementioned development and adjustment to companies' own outsourcing strategies in the fields of design, manufacture and logistics with the resulting adjustment of the number and structure of suppliers[9].

It is precisely the fact that purchasing volume is concentrated in a small number of direct suppliers and based on forcing product integration - system building - and creating higher-grade procurement units that causes those involved to expect a drastic reduction in costs and containment of the explosive expansion of variants in addition to expecting to be able to master the complexity of co-ordinating suppliers and logistics.

However, carmakers are using product integration and creating so-called systems, modules and sub-systems in an effort to deal with the problems described in the foregoing and to thereby secure competitive strength.

Despite numerous investigations conducted in this field, a number of important questions still remain unanswered that are especially relevant for the partnership-like relationship existing between carmakers and suppliers and between the individual suppliers in addition to bearing even greater potential in terms of increasing efficiency.

Therefore, this thesis aims to enhance detailed understanding of

(i) OEMs' system building strategy,

(ii) What OEMs expect from the various supplier levels (system/modules, sub-system, components) and

(iii) The main prerequisites for more efficient OEM/supplier co-operation with a focus on the development process.

This thesis is based on an empirical investigation and personal interviews conducted with key persons in automobile companies with the aim of painting a

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[9] See Fieten, R., Entwicklungsstrategien für Zulieferer, Gabler publishing 1991, p. 59; Prof. Herzog, in: Automobil Produktion, Dec. 1996, p.18; Macbeth, D.K./Ferguson, N., Partnership Sourcing: An Integrated Supply Chain Management Approach, Pitman Publishing, London, 1994, pp. 130-131

picture of the future situation and developing proposals based upon the information compiled.

Impulses leading to the research:

The scale of the dynamics resulting from changes in the automobile industry defies comparison with practically any other branch of industry in respect of the rapidly changing demands placed on safety, environmental friendliness, engineering and the market and in respect of the large number of businesses affected by these developments. The fact that this branch of industry assumes a dominant position within the overall economic situations of the individual highly advanced national economies of the USA and Canada, Western Europe, Japan and Korea, makes it essential to adapt to new structural and economic conditions as rapidly as possible in order to prevent detrimental effects on economic growth. Information that can be used as a basis for trend-setting decisions forms a prerequisite for rapid adjustment. New or additional information, as applicable, is of decisive importance in the field being researched: system-building. This field also affects the structures within organisations, the bases for joint work or company mergers, as applicable, and product-development activities and adjustment to the manufacturing structure, the results of which will not become evident for years. Decision-makers have come to realise that observing and optimising the overall relationship, especially the customer-supplier relationship, can provide opportunities to save enormous sums of money[10]. A few of these have already been taken advantage of, but there are numerous other ones that still remain unused. Inspired by the options that still have not been made use of, the author has tried to close an as yet not investigated, small gap.

[10] See Lloyd, A.R./Dale, B.G./ Burnes, B., A study of Nissan Motor Manufacturing (UK) supplier development team activities, in: Journal of Automotive Engineering, Vol. 208, 1994, pp. 63-68; Gaus, H., Noch effizienter entwickeln, in: Automobil Produktion, August 1995, pp. 32-33; Cole, G.S., The changing relationships between original equipment manufacturer and their suppliers, Congress Paper, IAVD Congress on Vehicle Design and Components, UK, 1987, pp. 121-144

Chapter Two: Review of literature

Obtaining an overview of the current state of research and the existing literature directly or indirectly relating to the subject at hand constituted the first step and formed the basis for the elaboration of the study.

The subject of system building and the demands from the respective levels of suppliers it implies form a relatively new field that did not start gaining attention until the early 1990s and still has not become established as an independent, clearly defined line of research. That is why no summarising studies explicitly dealing with this specific topic could be found. Although there are numerous publications relating to the subject areas at hand, most of these merely do so indirectly. As a result, they are unsuited for providing a comprehensive presentation of the tendencies emerging among European carmakers in respect of standardised product segmentation and demands on the part of suppliers and their relationships with carmakers. In view of the fact that the study's objective and elaboration in respect of contents are influenced by these related research activities, though, it would appear to be appropriate and necessary to provide an overview of the current status of research at this point. The report begins by explaining the topical classification for identifying relevant studies and then following this up with a discussion of the related contents and events as well as an extract of the conclusions and fundamental aspects of the research project.

Topical classification:

Searches of data bases of various libraries specialised in this field of research using variable combinations of the keywords, 'supplier structure', 'system integration', 'system', 'module' and 'supplier requirements'[11] formed the point of departure for identifying relevant studies and publications. The publications identified and the sources analysed in this manner in turn served as a basis for further research of literature.

[11] The literature research was conducted at several university libraries (Munich, Bamberg, Regensburg, Hertfordshire) and via Siemens' information research service, which has access to a huge number of national and international libraries. Despite the comprehensive study of literature, this study does not claim to be complete,. There were some international publications that the author did not not have access to.

Discussion of contents:

The study conducted by FEMERLING C. and EIKE v. H.[12] represents one of the few studies dealing directly with the author's topic. The tendencies of modular sourcing were studied in a primary analysis conducted within the (west) German motor industry. The study begins with a detailed description of the situation (employment, number of suppliers, manufacturing depth, structure of relationships) in the automobile industry in 1989 and the changes emerging in the procurement and production structure, and then goes on to investigate the following interrelated subjects and issues:

- Parts and components specific to vehicles that are suitable for modular sourcing
- Effects of modular sourcing on operational procedures and structures
- Effects of modular sourcing on production and procurement
- Extent and direction of changes with regard to the relationship between suppliers and buyers
- An analysis of future prospects and an estimation of future demands on module suppliers.

FERMLING and v.EIKE included a total of 180 suppliers in the study, 52 of whom actually participated. Empirical analysis led to the conclusion that there is significant potential in respect of parts and components that might be procured in the course of modular sourcing, whereas further spreading of the concept would essentially depend on carmakers' outsourcing plans, technical and technological changes and future developments in the automotive supplier industry. The following fields were rated as offering a high level of potential: Door trim panelling, dashboards, headlights, boot lids, doors, steering, axles, pedals and the central electrical system.

The study also concluded that the proportion of purchased parts will continue to increase due to the fact that all of the manufacturers claimed reducing depth of production as one of their goals. The relationship between the supplier and the buyer will increasingly assume a decisive role in respect of competitive strength in the motor industry. The fact that the company supplying the modules takes on a role as a general problem-solver inevitably results in it being forced to meet

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[12] See Femerling, C./Eike, v.H., Modular Sourcing, Schriftenreihe der Bundesvereinigung Logistik, No. 24, Munich, 1991

demands in order to secure this role. The analysis considered the issue from the carmaker's point of view and obtained the following ranking of the qualifications and capabilities expected of module suppliers:
1) R & D know-how, 2) high level of delivery service, 3) high level of quality of products, 4) just-in-time (JIT) competence, 5) flexibility,6) production know-how and 7) assembly facilities[13].

HACKENBERG U., Development Department leader at Audi AG, stated in his report[14] the need for general restructuring of the development process as well as the need for a clear definition of product groups and contents (systems, modules). As the main reason, he mentioned the progressively increasing number of development tasks which cannot be handled by the current development manpower. The product range at Audi for instance has doubled since 1990 with no remarkable increase in the number of employees.
The main points of the reorganisation of the development process at Audi were:

- early involvement of the supplier during the concept phase already,
- the specific use of the supplier's know-how
- the transfer of more responsibility to the supplier and
- the reduction of the number of suppliers by targeted promotion of system suppliers.

Product groups (systems, modules) were defined as a second step. The organisation of the project and system contents were specified in accordance with this definition. For instance, product groups at the Audi A3: Cockpit (includes heating and instrumentation), front-end, bumper, wiring harness, suspension, door, seat, exhaust system, tank, body and the sunroof.

In their report[15], THOMA P. and PREISSLER H.J., BMW AG, used a similar approach in presenting a product structure where system contents and responsibilities are linked and BMW handles system integration itself.
With the perspective of a value-added partnership between the OEM and supplier, the supplier must fulfil requirements by continuously increasing its competence

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[13] See also the ranking at Helper, S., How much has really changed between U.S. automakers and their supplier?, in: Sloan Management Review, Summer 1991, No. 15
[14] See Hackenberg, U., Methodik vernetzter Fahrzeug-Entwicklung am Beispiel A3, conference paper: Development perspectives for automobile manufacturer and supplier, Stuttgart, 13/14 Nov. 1996, chapter 5
[15] See Thoma, P./Preissler, H.J., Fahrzeugelektrik - gemeinsam zum Spitzenprodukt, conference paper, Innovations of automotive electronics, Stuttgart, 29/30 Nov. 1995, chapter 2

and global presence while also securing a successful position in order to be accepted as a system supplier.

Prerequisites for success for system suppliers:

- a leading position in relevant pacing technologies
- process orientation in development and manufacturing
- capability to manage sub-suppliers
- customer orientation
- modern communication systems and logistic systems.

An example of a product structure based on a BMW vehicle: Doors, body, seats, fuel supply, interior top part, interior floor part, brake system, front/rear suspension, exhaust system, transmission, steering, heating/cooling system, front-end, engine cooling system, wiring harness, central electric system, instrumentation/communication, cockpit.

WÜTHRICH A. and WINTER B. (1996)[16] take a similar view to that of FEMERLING C. and EIKE v.H. in their article titled "Zulieferer im 21. Jahrhundert" (Suppliers in the 21st Century) that deals with the demands that will be placed on future components suppliers. They use four trends influencing the strategic positioning of components suppliers as a point of departure, although they expand their role to include key competencies for components suppliers:

- A drastic reduction in the number of companies having direct contact with the manufacturer. There is a study that assumes that the number of direct suppliers will decrease by 30% to 60% between 1996 and the year 2001[17].
- Restructuring of the supplier industry into a pyramid-shaped structure with the subordinate components suppliers handing co-ordination tasks over to the system suppliers, who in turn will place partial orders with the components suppliers.
- Reduction of the depth of manufacturing from an average of 49% to approx. 36% by the year 2000. Mention is made of the fact that DaimlerChrysler (Stuttgart) and BMW are convinced that the production of body shells, painting and assembly are the only areas that will continue to form part of carmakers' core business in the long-term. This would cause the depth of manufacturing to

[16] See Wüthrich, H.A./Winter, W.B., Zulieferer im 21. Jahrhundert: veränderte Spielregeln – neue Schlüsselkompetenzen, in: Management Zeitschrift, 1996, No. 6
[17] See also study of Scientific Consulting, Dr. Schulte-Hillen, in: Wirtschaftswoche, 1995, No. 29, p. 12

decrease to approx. 15% and the volume of procurement to increase drastically as a result[21].

- An increase in global sourcing and single sourcing along with an expansion of the over-all supply activities extending beyond the life cycle of the end product.

In their survey conducted in 1997, the A.T. KEARNEY[18] business consulting agency used a standardised questionnaire to survey 258 persons in 175 North American companies and 26 personal interviews with persons from senior management. They analogously came to the conclusion that product integration will constitute one of the four core points influencing automobile suppliers in the future, along with globalisation and consolidation of a reduction in suppliers. The study also found that global presence and system integration capabilities are more important than the prices quoted when selecting suppliers. They defined system integration as having four functions:

- Technological integration, e.g. an integrated driver information system
- Modular integration, e.g. a module with integrated air-intake and fuel rails
- Integration of service, e.g. integration of all of the electronic systems – assembly concept
- Integration of processes/functions, e.g. all electronics from a single supplier.

BOSSARD Consulting[19] went a step further in their study and described a supplier scenario in the year 2010 based on their investigations. They conducted interviews with a total of 28 top managers at OEMs' and suppliers'. The authors concluded that the increasing demand for modules and integrated systems was a result of the reduction in the depth of manufacturing and development at the automobile manufacturers, whereby their results confirm the findings of previous studies. Here, we find a link between the reduction in the depth of manufacturing and the increase in modules and between the decrease in the depth of development and the increase in integrated systems.

The future components suppliers pyramid resulting from these analyses is shown in Figure 2.1 as a visual aid.

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[18] See A.T. Kearney, Investigation report, The changing roles and responsibilities in the 21st century automotive supply chain, May 8, 1997

The paradigms for the components supplier scenario in the year 2010 were then constructed based on these investigations:

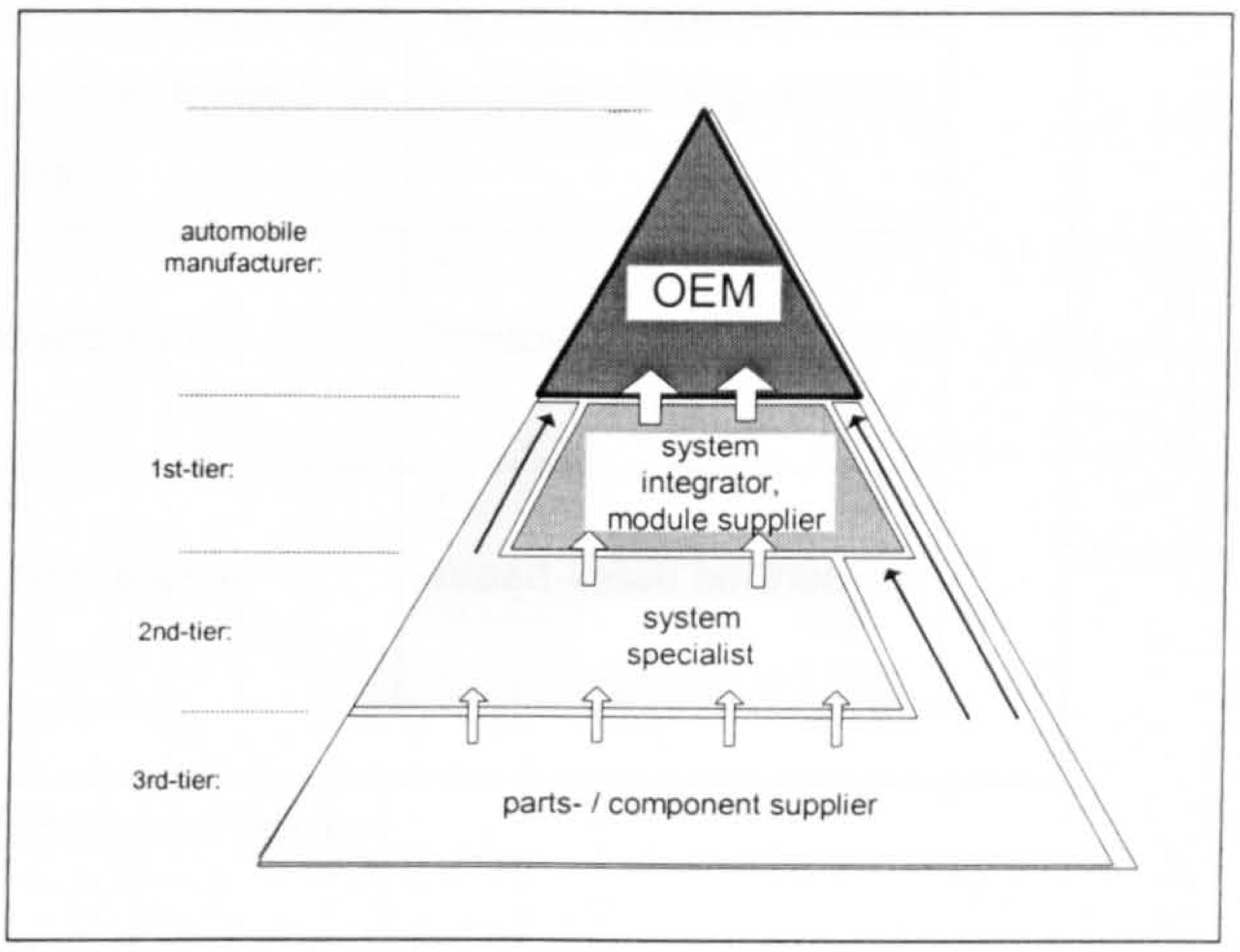

Figure 2.1: Supplier structure based on the Bossard-study[19]

- OEMs will experience a decrease in purchasing power due to the small number of system integrators.
- There will be less than 20 mega-suppliers acting as system integrators.
- The mega-suppliers will enhance their value creation and competence by taking more system specialists on board.
- There will be numerous project-specific, horizontal partnerships between a small number of globally active system specialists.
- The smaller and medium-sized parts and components suppliers will need to reorganise to improve professionalism and specialisation.

In the study, the general manager of a major car corporation criticises an article published in "Management Magazin" [20]:

"Nobody disputes the concentration in the PS branch of industry as described in the Bossard study. However, 'in its generality', states the manager of a carmaker in Southern Germany, 'the study lags far behind the actual developments'. The former manager of Ford-Werke AG, William Boddie: ' I don't think that there will only be 20 mega-suppliers with a group of components suppliers attached to them in addition. At any rate, that's not what we want.'"

Granted, WILDEMANN does not sketch any scenario of the future, but he does use a similar classification of components supplier companies according to types that is similar to that used in the Bossard study. The studies do, however, differ in respect of the terminology used. Among other findings, he presented the following typology (Figure 2.2)[21].

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[19] See Bossard Consultants, Kooperationen und Partnerschaften zwischen Lieferanten der ersten und zweiten Zulieferebene, Investigation report, Bossard Consultants, Frankfurt, October 1996

[20] See Herzog, M., Muster ohne Wert: A study about the future of the automobile industry created some confusion in the automotive area, in: Manager Magazin, February 1991, pp. 31-33

[21] See Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, Munich, 1993; and also, Fieten, R., Entwicklungsstrategien für Zulieferer, Gabler publishing, Wiesbaden, 1991, p. 60

performance / competence of the supplier	Using the products and processes pre-defined by the customer	System expertise and problem-solving abilities
Production know-how	A Parts manufacturer	B Production specialist
Production know-how and product know-how	C Development partner	D Added-value partnership

Figure 2.2: Different types of suppliers

By contrast with the BOSSARD study, the research report by WILDEMANN comprises a comprehensive description of the changes in the motor industry and the components suppliers industry. Here, the investigations are not merely limited to national concerns, but also deal with international circumstances and changes. In addition to dealing with the BOSSARD study, which provides general guidelines relating to potential product segmentation by defining and integrating the terms, "system" and "module", and by classifying a few examples, WILDEMANN restricts himself to a general description of the requirements placed on the individual supplier segments[22].

WOLTERS, KARSTEN and THORWITH[23] describe similar structural changes in their essay titled "The system integrator will come" in which they comparing to those referred to in the BOSSARD study. They assume that project management will be the future key to success. This statement is reinforced by a study conducted by CLARK, KELLER, MONGE/MILLER and FUJIMOTO[24].

SCHINDELE S.[25] provides further references to the process of creating systems and modules along with the effects on the structures in the motor industry that may

[22] See also, Fieten, R., Entwicklungsstrategien für Zulieferer, 1991, p. 93
[23] See Wolters, H./Karsten, H./Thorwith, A., Der Systemintegrator wird kommen, in: Automobil Produktion, Oct. 1995, pp. 40-42
[24] See Fujimoto, T., Organisation for effective product development: The case of the global automobile industry, PhD thesis, Harvard University, 1989, pp. 428 ff.; Keller, R.T., Predictors of the performance of project groups in R&D organisations, in: Academy of Management (Journal), 1986, Vol. 29, No. 4, pp. 715-726; Miller, K.I./Monge, P.R., Participation, satisfaction, and productivity: A meta-analytic review, in: Academy of Management (Journal), 1986, Vol. 29, No 4. pp. 727-753; Clark, K.B., Project scope and project performance: The effect of parts strategy and supplier involvement on product development, in: Management Science, Oct. 1989, Vol. 35, No. 10, pp. 1247-1263
[25] See Schindele, S., Entwicklungs- and Prozeßverbünde in der deutschen Automobil- und Zulieferindustrie unter der Berücksichtigung des Systemgedankens, PhD thesis, Shaker publishing, Aachen, 1996

be derived from them. They present the change in the relationships and joint work of carmakers and their suppliers and among the suppliers in a written survey of 300 suppliers based on a standardised questionnaire. Beyond that, they have used a very clear and easy-to-follow format to illustrate how the terms, 'system' and 'module', are used by manufacturers and suppliers. The examples cited illustrate clearly the diverse classifications and approaches in respect of systems and modules. They also discuss – usually in a general fashion - what aims are being pursued with the change in the procurement structure and what demands are being placed on the corresponding suppliers in each case.

The inconsistent assigning of terms and products among carmakers results in a blurred picture of the number of systems and modules[26] currently used at the manufacturers'. For instance: Renault uses 150 modules and systems, the PSA-Group uses 260 systems, DaimlerChrysler (Stuttgart) uses 250 systems[27], Ford uses up to 50 systems per vehicle, BMW uses 40 modules and Porsche uses 30 to 50 modules.

The statements on the development of systems/modules per vehicle reflect the outcomes of the interviews with Mr. Becker, former Head of Purchasing at BMW, and Mr. Iffland, Head of Purchasing at Audi printed in the professional journal, "Automobil Produktion" (Automobile Production)[28].

According TO SEIFERT [29], these changes and the trend toward system building will produce significant potential for growth for electric/electronic suppliers due to the over-proportional rates of increase in the share of electrical parts and electronic parts in cars. SEIFERT cites two essential reasons for this potential for growth: a) The developing of new systems that meet environmental requirements and the desire for better performance and more luxury and safety and b) the fact that electronic systems have penetrated the medium-sized and small-sized classes. The proportion of money spent on electrical/electronic systems in

[26] Kleinert, G., stated that the cost of a cockpit of a car could be reduced by 20% through the definition and use of modules, in: Automobil Elektronik, Eine Branche strukturiert um, April 1994, pp. 22-23
[27] See, w.A, Sublieferanten: Chancen in der zweiten Reihe, in: Automobil Produktion, 1996, p. 20
[28] See Automobil Produktion, Aug. 1996 pp. 34-36; and, Automobil Produktion, June 1997, pp. 24-26
[29] See Seifert, H., A question of integration, in: Automobil Industry, Mai 1994, pp. 54-57

proportion to the manufacturing costs for one vehicle will increase from approx. 20% in 1990 to over 26% in the year 2000[30].

The following provides an overview of the literature review regarding future supplier requirements for the individual supplier segments (system, sub-system, components) and the main aspects of the changing relationship between customers and suppliers - with the focus on more efficient development process - due to the system building approach and the change in the supply structure (pyramid-shaped structure).

When taking a look at the topic - the changing relationship between customers and suppliers with a focus on more efficient development process -, which after all provides a comprehensive view of the over-all product development value chain in the motor industry, we find relevant literature to be rather scarce. Moreover, studies and papers concentrate on a wealth of publications from the corresponding specific individual fields, particularly in the area of logistics and in the areas of quality management and information management, or they are restricted to internal[31] or bilateral individual examinations[32].

WILDEMANN AND FIETEN[33] are among the few who present the success factor/competencies based on the individual supplier segments (Table 2.1). However, the supplier segments Fieten refers to differ from those defined by BOSSARD and WILDEMANN.

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[30] See Preuß, E., The future of the automotive electric and electronic, conference paper: Development perspectives of automobile manufacturer and supplier, Stuttgart, 13/14 Nov. 1996; Chapter Six of the conference handout; and, Automobil Produktion, Feb. 1998, p. 22

[31] See Tanaka, Y./Britton, P.L., Successful fabricator/supplier partnership through targeted product development, PCWC VII, Basel, 1996, pp. M3/1-7, this paper gives a good overview about internal changes for a better product development process.

[32] See Arnold, U., Value-added partnerships as potentials for success, in: Beschaffung aktuell, Oct. 1993, pp. 20-24

Supplier Segment	Necessary success factors / competencies
Standard products	Productivity increase Supply service
Know-how products without patent limitation	Productivity increase Supply service Product quality
Innovative products with patent limitations	Productivity increase Supply service Product quality Development service
Complex modules and systems	Productivity increase Supply service Product quality Development service Integration capability

Table 2.1: Supplier requirements based on Fieten[33]

E. GEYSEN[34] contrasts with the aforementioned authors in that he only refers to the first level of the supplier structure and divides the success factors for a system supplier into four different categories.

- General factors:
  - clear company strategy
  - stable conditions of income
  - global orientation
- Technical factors:
  - development potential and innovation potential
  - research and development orientation
  - competitive technology
  - potential of manufacturing optimisation
  - quality-orientated development and manufacturing (ISO 9000)
  - logistic concepts / JIT competence
- Organisational factors:
  - competence in dealing with sub-suppliers
  - flexibility
  - open to co-operation with reference to all business issues
  - Total Quality System
  - efficient logistic system
  - compatible computer systems

[33] See Fieten, R., Erfolgsstrategien für Zulieferer, Gabler publishing, Wiesbaden, 1991
[34] Geysen, E., Neue Wege in der Beschaffung, in: Beschaffung aktuell, 3/94, pp. 39-40

- Economic factors:
  - cost orientation
  - profit orientation

SCHÜRMANN's[35] point of view differs from the one just presented. Based on the drastic changes the automotive supplier are confronted with (supplier reduction, change of the supplier structure) he relates the requirements of the automotive supplier to the three factors market, customer and competitor.

Market-driven requirements	Manufacturer-driven requirements	Competitor-driven requirements
* individual solutions * fast reaction times	* high logistic and quality standards * assuming of development costs * installation of production capacity near the customer	* a lean organisation * concentration on core business * customer-specific standards * reduction of production time

* recycable vehicles
* state of the art environment technology
* ability to handle a huge rate of variants

* innovative customer-supplier relationship
* modular production structure

WINGERT[36] investigated did a general investigation of how more intensive supplier integration will influence the strategic establishment and optimisation of the supply/development relation in order to gain competitive advantages. Based on literature research and empirical investigations, she identified the factors of integration, flexibility, orientation and quality as core capabilities or strategic variables for enterprises. She indicated that proper adjustment of these strategic variables can make customers and their suppliers more successful than other comparable relationships in the value-added chain. She suggested a concept based on three steps for optimising the division of labour among the parties involved:

- Identify current and future core activities and competencies.
- Define the depth of development and manufacturing based on the overall cost calculation (transaction cost, logistic costs and production costs).
- Define the appropriate interfaces.

[35] See Schürmann, D., Vom Diener zum Partner, in: Absatzwirtschaft, edition 4/94, p. 42-45
[36] See Wingert, G. M., Wettbewerbsvorteile durch Lieferantenintegration (Competetive advantages through supplier integration), Gabler publishing, Wiesbaden, 1997

She stated that success is highly dependent on the work-and-exchange relationship between the customer and the supplier, particularly in development, logistics, production and quality, which require new forms of interaction in external relationship management and internal organisational and structural changes. Using a comparison as a basis, she concluded that companies with intensive supplier integration are more successful, have better operative performance and are more productive and competitive than those with lose supplier relationships. These can be achieved by intelligent supply chain management and proper adjustment of integration, flexibility, orientation and quality.

The subject of improving the relationship in the value-added chain by earlier supplier integration is covered in more detail by PETER[37]. Many companies still have difficulty utilising their suppliers effectively, because they involve them too late in the development cycle or without a systematic approach. The purpose of his study was to enhance understanding of how to involve suppliers early on in the product development process. His work focused on eleven key issues that form success factors for early supplier involvement (1. Standardisation, 2. Design freeze, 3. Supplier selection, 4. Supplier source, 5. Number of suppliers, 6. Supplier localisation, 7. Minority sourcing, 8. Role of purchasing, 9. Pricing, 10. Communication, 11. Commitment) and identified potential barriers and conflicts that may hinder smooth deployment of ESI. He mentioned that the most fundamental decision is that to integrate the relevant aspects of early supplier involvement in the existing processes rather than create a new stand-alone process. He also suggested that the *"developed assessment tool of the eleven key decision areas can be used as a baseline to analyse the current situation of a project, to determine the desired position for each decision area, and to derive the corresponding metrics".*

TOWILL[38] starts out with a dynamic examination of the ordering and delivery processes in the semiconductor industry and goes on to describe the extent to which costs can be reduced if all of the parties involved in the development process are integrated in the overall process more effectively. He points out that

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[37] See Peter, M., Early Supplier Involvement (ESI) in Product Development, PhD thesis, University of St. Gallen, 1996

[38] See Towill, D.R., Supply chain dynamics, Int. J. Computer integrated manufacturing, 1991, Vol. 4, No. 4, pp. 197-208 ; regarding information integration model, see: Evans, G.N./Naim, M.M./Towill, D.R., Dynamic supply chain performance: Assessing the impact of information systems, in: Logistic Information Management, Vol . 6, No. 4, 1993, pp. 15-25

information systems have already been identified as the key factors for optimum management of the supplier chain[39].

This finding is also confirmed by THALER[40] who reaches the conclusion that the exchange of information between buyers and suppliers is still in dire need of improvement. However, a small number of suppliers on the first and second levels make use of the data networks available on the market for the intensive exchange of information with their customers.

In their study, HARTLEY/MEREDITH/McCUTCHEON and KAMATH[41], interviewed design engineers in 79 small and medium-sized businesses to determine the influence that the three variables of a) timing of the supplier's integration, b) supplier's responsibility for design and c) frequent communication had on the design process. Their conclusions were as follows:

- They found a statistical correlation between the variables of a) timing of the supplier's integration and contribution to product development. This is advantageous in terms of time and costs.
- They did not find any correlation between the variables of b) supplier responsibility and contribution to product development. What was surprising was that there was a correlation between the variables of c) frequent communication and contribution to product development.

Contrary to the statement from earlier studies by FITZGERALD, HARTLEY/ZIRGER/KAMATH and ZIRGER/HARTLEY[42], namely that integrating the suppliers soon does not necessarily contribute to a reduction in the time required for design, this study concluded that the likelihood of achieving technical goals becomes much higher with early integration.

[39] See also Jones, C., Supply Chain Management: The key issues, BPIC Control, Oct./Nov. 1989, pp. 23-27
[40] See Thaler, K., Schlank, aber für die Zukunft noch nicht fit genug (but not fit enough for the future), in: Beschaffung aktuell (Current procurement), April, 1995, pp. 53-56
[41] See Hartley, J.L./Meredith, J.R./McCutcheon, D./Kamath, R.R., Supplier's Contribution to Product Development: An exploratory Study, IEEE Transaction on Engineering Management, Vol. 44, No. 3, August 1997, pp. 258-267
[42] See Fitzgerald, K.R., For superb supplier development Honda wins, in: Purchasing, Vol. 119, No. 4, 1995, pp. 32-40; Hartley, J.L./Zirger, B.J./Kamath, R.R., Managing the buyer-supplier interface for on-time performance in product development, in: Operation Management, Vol. 15, No. 1, 1997, pp. 57-70; Zirger, B.J./Hartley, J.L., The effect of acceleration techniques on product development cycle time, IEEE Trans. Eng. Management, Vol. 43, May 1996, pp. 143-152

In his article, PETERS[43] addresses three core factors viewed by automakers as constituting the foundation for promoting innovation and considered the basis for a future win-win situation:

- partnership
- trust
- exchange of information.

A representative survey of 450 automobile suppliers (1995) yielded results that tended to impede the promoting of innovation.

- Businesses in the electronics field were treated more like partners than in the field of rubber and plastic processing.
- Announced plans to single-source, which induced the component suppliers to invest large sums of money in R & D, were converted into multiple-sourcing.
- Companies were forced to disclose technological know-how without any previous contractual commitment.
- Abuse of information that had been transferred .

Conclusions and critical examination:

Literature research resulted in the following conclusions and critical comments in respect of the issues for study that have been selected by the author:

- The changes in the automobile industry and the resulting consequences for the components suppliers are covered very well in the literature.
- The literature shows clearly that procurement strategies are changing from the purchase of simple parts and components to the purchase of higher-grade units
- The number of individual carmakers' direct suppliers will decrease further.
- Studies were found assuming that the supplier structure can be subdivided into 3-4 segments, each of which are assigned different requirements.
- The structure tends to narrow toward the top (pyramid shape), where we find the suppliers who have direct contact with the carmakers, whereby carmakers are highly sceptical of having any supplier hold too much power.
- The suppliers who are at the first level are commissioned to handle co-ordination of the value-added chain, which in turn influences project management and information management.

[43] See Peters, J., The customer as a check for innovations, in: Automobil Industrie, Mai 1996, pp. 10-11

- The literature research yielded 6 core prerequisites for optimising the development chain and reducing the time and financial resources required for development as a result:
  Mutual trust, an atmosphere of partnership, early integration of all those involved in the development process, optimum distribution of information, and optimum co-ordination.

The following are viewed critically:

- Most of the studies are restricted in scope and primarily cover the fields mentioned in the above. No detailed investigation of possible standardisation of system building (system segmentation scenario) among European car manufacturers has been conducted to date.
- Neither carmakers nor suppliers have a manifest clear definition and classification for "system" and "module", both terms used in connection with product integration.
- Beyond that, there is no rated comparison of the requirements applying to the respective supplier segments among European carmakers. Although many publications give indications, these are all limited to descriptions of situations in individual companies.
- Based on the author's knowledge to date, there has not been any detailed classified examination and representation of the primary factors making up a more efficient development process and interaction between the manufacturer and the system supplier - the development value chain - that takes increasing product integration and shorter development times and reduced budgets into account.

All in all, the impression that there is not sufficient information - neither theoretical nor information from empirical research - available to date in the field of product segmentation that might serve as a basis for an investigation examining hypotheses is gradually developing into certainty. Not only that, there appears to be an urgent need for additional thorough explorative investigations aimed at improving verification of potential.

Chapter Three: The research project

3.1 Objectives

The research paper at hand is directed at two primary interrelated target dimensions. The aims that have been set here are oriented toward scientific relevance on the one hand and at potential in terms of actual practice on the other hand.

The first aim is defined by the scientific foundations and results emitting from a demand placed on research, namely that of contributing to closing the existing gap in the research being done in this area of the automobile industry. Using a detailed analysis of literature and a delimitation of the existing gaps as a basis, this paper aims to verify:

(i) How automobile companies will proceed in developing their system-building strategy.

(ii) What OEMs expect from the individual supplier levels (system, sub-system, component supplier).

(iii) Major changes in the customer-supplier relationship and the main prerequisites for more efficient co-operation with a focus on the development process.

Accordingly, the study seeks to find answers to the following questions:

(i) Can a common trend toward system building (system segmentation scenario) be identified among OEMs?

The study aims at finding out whether there is a trend toward standardisation with reference to system building, or whether the supplier sector must adjust to highly diverse constellations of products and of procurement as a result. All of this in turn has significant effects on the supplier companies' orientation in terms of organisation, flexibility and strategy.

(ii) What specific requirements apply to suppliers with respect to the individual supplier levels (how do these differ?)?

The study examines the demands placed on suppliers with reference to the individual segments while taking the changes in system integration into account. It aims to show whether the profile requirements applying to the individual supplier levels (system, sub-system, component) differ from one carmaker to another. The criteria are subdivided according to their relevance to engineering, logistics, quality and service.

(iii) What are the main changes to be expected in the future relationship between customers and suppliers, and what are the major prerequisites for a more efficient development process?

In the course of a process where the depth of design/manufacturing has gradually decreased, the level of product integration and complexity has increased, the extent of procurement has grown to concentrate on a small number of supplier businesses and concomitant changes have taken place in the structure of the supplier segment. The extent of co-ordination and the tasks involved on the suppliers' part have also shifted, particularly when businesses are direct suppliers (first-level supplier). Therefore, an attempt must be made to ascertain the actual state of and changes in collaborative product development by the customer and the supplier, which is already marked by the pyramid-shaped supplier structure, and to verify its potential for improvement by using it as a basis.

Finding answers to these questions should be very useful to the individual supplier in determining their internal organisational structure and the conditions of the development process the automobile manufactures and suppliers are involved in. Beyond that, the answers would also be useful for resource allocation and for making strategic decisions in respect of alliances and collaborations while preparing a business for the even fiercer competition that will characterise the automobile-supplier market of the future.

3.2 Contribution to the existing knowledge base

The study uses the above-mentioned topics as a point of departure to focus at:

(i) Developing an optimised organisational model for the automobile supplier.

(ii) Evaluating the necessary level of requirements for each supplier segment and pinpointing possible differences.

(iii) Developing a more efficient model of customer-supplier co-operation with a focus on the development process.

(iv) Working out rules for such optimised development and co-operation.

(v) Working out important strategic factors that automotive suppliers take into consideration for future planning.

3.3 Methods and conceptual framework

Methods:

Each and every field of science and scientific papers aim to increase knowledge and insights (insight goal). When taking a look at the natural sciences and social sciences, one notes in particular that detecting and recognising structural properties of realities are what interest most. Hypotheses are set up to this end and condensed into laws that are then used to provide the foundation for the theories that have been developed. However, empirically tested statements about laws are not only needed for describing and classifying; they are also especially important when it comes to systematic recording, prognosis and shaping of certain structures and processes of reality[44]. Used in this context, the term empirical refers to the examining of theoretically worded assumptions on the basis of specific reality[45].

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[44] See Schanz, G., Methodology for business administration, p. 11; and, Kromka, F., Methodology of social science, p. 43

[45] See Popper, K.R., The Logic of Scientific Discovery, New York, 1959, pp. 27-30; and , Attelslander, Methods of the empirical social research, 7th edition, pp. 13

This insight with reference to a field of objects as already discussed is used as a point of departure for the study. Furthermore, the author decided to apply the method of empirical investigation to identify the specific subject area that is as yet unknown or little known with

- a standardised questionnaire for compiling data and
- descriptive statistics and explorative data analysis for the presentation and examination of data.

According to FRIEDRICHS[46] , the implementation of scientific thought in the form of systematic steps of research presupposes a research procedure that can be divided into three steps:

- Context of discovery: Refers to the event that led to an investigation.
- Context of justification: This refers to the methodological steps involved in investigating a subject of research.
- Context of application: This step is the final step and represents the contribution made by an investigation toward answering the questions posed at the beginning.

As already mentioned at the beginning, in addition to being subject to the difficulty of determining information with relevance for actual practice and structuring and integrating such information in an engineering and business context, the investigation is also subject to the current relevance of the topic in particular, as the activities take place in a constantly changing environment. Beyond that, the use of empirical research methods entails the risk of having questions directed at the persons surveyed not always being interpreted the way the investigator thought they would.

An empirical investigation generally presupposes precise wording of a problem and mastery of a method that is oriented at solving the problem at hand. A standardised questionnaire was selected as the means for obtaining information that was relevant to actual practice. The decision to use a questionnaire was made on account of the fact that this method cost less and required less time than personal interviews. It was planned to only use personal interviews when additional detailed information about interpretations, opinions, perceptions and

[46] See Friedrichs, Methods for the empirical social science, p. 13 and p. 107

vague statements in the questionnaire was required and to verify the results obtained.

A questionnaire for a written survey generally requires a higher degree of precision than the steps followed when doing an interview. Due to the fact that the reader must be able to understand a questionnaire without any additional explanations, special attention must be paid to the wording so that it is easy to understand and concise. Preliminary pre-tests were conducted in order to assess reactions regarding the contents and structure with a view to improving the questionnaire. Interviews conducted with the persons who filled in the questionnaire served to determine interpretations, opinions, perceptions and vague statements. All of the persons surveyed worked for European carmakers with most of them in purchasing or in strategic departments for planning and strategy development and the others in engineering. The subjects were selected according to the amount of influence they could have on business policies and their confirmed decision-making power. As the information obtained needed to be reliable and confidence-inspiring, the subjects were predominantly members of the senior staff (upper management level) of the relevant strategic departments within the technical and purchasing areas with positions allowing them a significant degree of influence, decision-making power and transfer power with reference to the topics being investigated. Persons working at lower levels were also surveyed in order to check for possible different trends within one company.

The corresponding subjects were found by going through the relevant companies' publications, contacting their press departments and then contacting them personally. The network of personal contacts at Siemens Automotive was used to obtain the desired information. The following carmakers were contacted: BMW, Daimler Chrysler (Stuttgart); MCC, Audi, VW, VW-light trucks, BMW M GmbH, Seat, Volvo, Ford, Sogedac[47], Opel, Skoda, Porsche, Renault, Fiat, and the Japanese companies, Nissan, Honda and Toyota.

The descriptive statistical method and explorative data analysis are well suited for the field of research at hand and the kind of information gathered. The descriptive statistical method is a method by which a large volume of data is condensed and

[47] Sogedac is the purchasing division of Peugeot and Citroen

the data properties are visualised using only a few significant figures (mean value, standard deviation etc.). There are cases where only one figure is used to represent all of the figures in an investigation. Visualisation may be in the form of tables, figures or statistical values. The descriptive method was found to be best for achieving the aim of the investigation with a view to the investigations required and the type and amount of data to be collected. By contrast with the descriptive method, the inductive method describes a research process by departing from specific items and proceeding to general items or by starting with a single element and moving to the whole object. That means that the general items or the whole object will be derived from specific details or a corresponding single situation. For instance, if a person A is late several times, the conclusion will be that this person will always be late in the future. Application of the results obtained from a sample group within a defined research area to an entire population base is an example of the inductive method. The inductive method was not suited for the project at hand, as it was not possible to draw a general picture based on information from just one sample (e.g. simply because an OEM follows a certain path does not mean that this is representative for all other OEMs). Classic fields of application for the inductive method are probability calculations, interval estimations or statistical estimation methods[48].

The term, explorative data analysis, merely refers to the investigation of a field that is as yet unknown or little known. Whereas the automobile industry is generally very well known, the specific areas described in Point 3.1 have not yet been identified and explored thoroughly. Therefore, the research project at hand aims to provide exploratory investigation of new facts, relations and conditions.

The effects on the product-development process triggered by the changes mentioned earlier were examined by taking a look at a system supplier (please refer to section 7.4 for more details on this investigation.)

[48] see Bamberg, G./Bauer, F., Statistics, 7th edition, Oldenbourg publisher, Munich, Wien, 1991; Milbrodt, H., Deskriptive Statistik, lecturer manuscript, Statistic course, Uni-Bayreuth, 1990, pp. 4-12

Conceptual framework:

The theoretical and practical aims derived while setting the tasks were a determining factor in arranging the contents of the paper. All of this has resulted in a conceptual structure based on BIRCHER[49] that serves as a kind of red thread as shown in Figure 3.1, which shows the paper's structure and procedures.

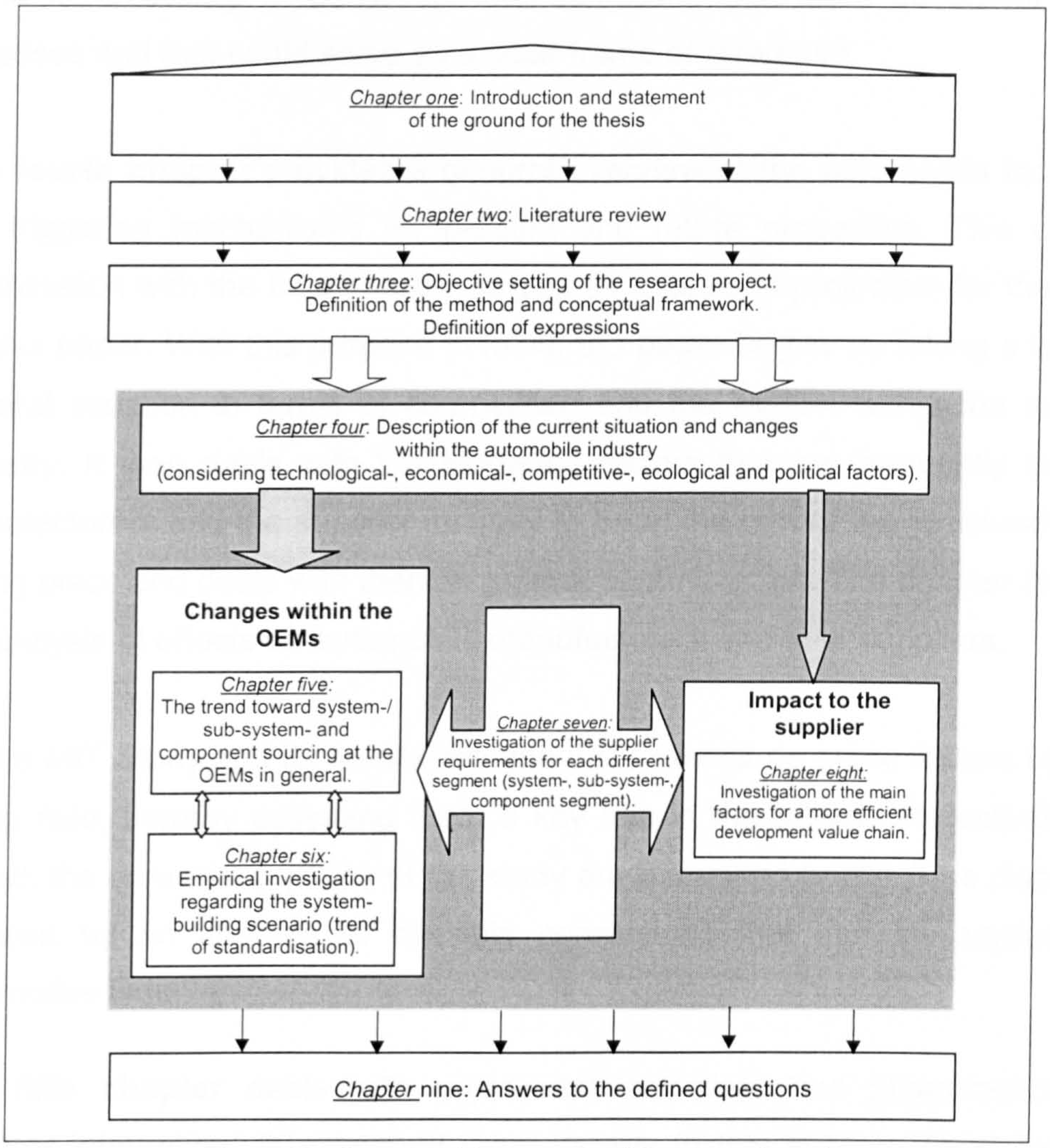

Figure 3.1: Conceptual framework of the research work

The paper is divided into an introductory chapter and five main chapters.

The motivating factors for conducting the investigation were presented at the beginning of the **first chapter** using the extensive literature analysis performed as a basis, which is presented in the **second chapter**.

The **third chapter** contains a statement of the research project objectives and the evaluation scale used as a guideline in the investigation. This is followed by a

[49] See Bircher, 1976, pp. 32 ff.

presentation of the conceptual framework and the procedures for achieving the objectives that have been set.

Although the use of terms and their classification is important in this paper, terms have been treated rather ambiguously in past investigations. Therefore, the author found it necessary to come up with definitions that were suited for research purposes and that could serve as a clear frame of reference.

The **fourth chapter** provides a general overview of the automobile industry and the triggering mechanisms for present and future processes. This chapter in combination with the third chapter served as a basis of projection for the aims set for this paper. With this purpose in mind, the paper begins by taking a look at the general situation in terms of competition and the market within the automotive industry. It then deals with the triggering factors that are frequently thought by manufacturers and the supplier industry to be at the root of the structural changes taking place and deals with them in greater depth later on. The chapter closes with an analysis of effects on automobile manufacturers and their suppliers.

As the MIT Study and its results are generally viewed as prime factors by experts in the field, thereby assigning them a key role in the adjustment activities being forced, the core assumptions of the study are discussed briefly. This discussion is followed by an analysis of possible conclusions that can be applied to the automotive industry.

The **fifth chapter** deals with adjustment activities. The phenomenon called "product integration" is examined more closely in this section. Here, the author starts out by attempting to verify the driving forces leading to an increase in product integration and then goes on to ascertain further measures to be derived from these. These include, for example, the explosion of the diversity of variants, increased complexity and the immense cost pressure resting on manufacturers' shoulders, just to name a few in advance.

The previous situation of product integration is then illustrated using examples, and reference is made to the opportunities and risks for suppliers.

Chapter Six contains an empirical analysis of the system-building scenarios of the carmakers who participated in the study. The key question of how the individual procurement units will be defined in the future and what the respective assignment of carmakers to the supplier segments will look like are of primary concern in this section.

The study aims at finding out whether there is a trend toward standardisation with reference to system building, or whether the supplier industry must adjust to highly diverse constellations of products and, as a result, of procurement. All of this in turn has significant effects on the supplier companies' orientation in terms of organisation and strategy. The year 2007 is defined as a time reference (period) in this context.

The empirical analysis of the future joint work of carmakers and components suppliers presented in **Chapter Seven** uses **Chapter Six** as a point of departure. It goes on to analyse the demands placed on the suppliers with reference to the individual segments, taking the changed system-building scenarios into account. It is aimed at elaborating a presentation that shows whether the required profiles with reference to the individual supplier levels (system, sub-system, component) differ from one carmaker to the other. The criteria are subdivided into aspects that are relevant to engineering, logistics, quality and service.

Chapter Eight then deals with the consequences of increasing product integration for the changing customer-supplier relationship and attempts to identify the main prerequisites for more efficient co-operation between the parties with a focus on the development process. In the course of a process where the depth of design/manufacturing has gradually decreased, the extent of procurement has grown to concentrate on a small number of supplier businesses and concomitant changes have taken place in the supplier structure. The tasks of and extent of co-ordination work on the part of the suppliers have also shifted, particularly in the case of the businesses acting as system suppliers (first-level suppliers). Here, the results refer to the study of a link in this product development chain. An extensive examination, taking all of the businesses positioned at the front or rear of a chain would have exceeded the scope of this study. A case study of an automotive supplier[50] is used to examine the consequences, necessary changes and future significant factors for success. Due to the fact that the investigated supplier normally has direct contact with the carmakers in respect of the development and manufacture of its products, it was possible to arrange this study such that both interfaces, the link to the carmaker on the one hand and the link to its sub-suppliers on the other hand, could be analysed in detail. On account of the restricted range of vision offered by this analysis, it does not claim to be complete. However, it does provide the opportunity to use a comparison with an own internal situation and to localise weak points and introduce measures to rectify them. This was considered an enrichment when taking the analogy with other businesses and development processes into account.

53 project managers working nationally and internationally participated in the study performed[51]. A standardised questionnaire was used to cover the range of topics including project composition (internal/external), exchange of information, mutual trust, co-ordination and change management and methods and tools. An attempt was made to ascertain the actual state of product development processes that were already predominantly characterised by the pyramid-shaped supplier structure of suppliers and to verify its potential for improvement by using it as a basis.

The **ninth chapter** concludes with a summary of the project, a critical examination of the contribution of existing knowledge and opportunities for additional research activities.

3.4 Definitions of terms

Any scientific research project starts out by defining terms, thereby permitting precise recording and classifying of the aspects that are relevant in the study. However, fundamental difficulties may occur when doing so, such as when one and the same term is assigned different meanings and definitions in colloquial language as well as in the language used for communication between institutions

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[50] The investigated supplier is a major automotive supplier of electronic/electric systems/sub-systems and components with world-wide over 20.000 employees and a turnover of about 5,5 Bill DM (figures are from '99).

[51] The product development organisation is based on the strategic business unit concept with a heavyweight project leader who is responsible for the development budget, the project development plan etc.

and businesses. The following definitions of terms used as a point of departure for the study are intended to counteract this.

Systems and modules:

System, (module) and sub-system constitute the essential terms that the paper is based on. The term, system, is generally relative, so that it is difficult to determine unmistakably what is referred to as a system and a sub-system.

In the approach used in the following, the frequency of use of the respective terms in actual practice serves as a basis for providing general system definitions from the point of view of system theory and transferring these to the overall system of vehicles. According to KIRSCH[52], a system comprises a number of elements (parts, components) that are interrelated and exhibit links in respect of contents, energy and informal links and, as a result, records and process material, energy and information. ULRICH[53] views a system as "an ordered entity of elements with some kind of relationships existing between them or with the potential of creating such relationships". According to ULRICH, this means that we can refer to almost all objects as systems. DANZER[54] defines a system as a collection of units that are interrelated. There is no defined hierarchical structure of the elements. Whenever it appears expedient, parts of a system can be grouped as sub-systems, or a number of systems can form a new, super-ordinate system.

We may then conclude that a system is a collection of parts and components that are interrelated and that are capable of being subdivided further. When we transfer this insight to a vehicle as an overall system, we find that, depending on the delineation selected, it consists of a multitude of systems that are normally interrelated functionally. In the final analysis, the interaction of all of its systems, sub-systems and components are what yield the vehicle's ability to function. Viewed from a standpoint of system theory, this would be an unambiguous application of the definition.

Beyond this, we need to also concern ourselves with the concept of modules, which may be considered a special form of a system according to the foregoing explanation. When used colloquially in the motor industry, a system that is limited

[52] See Kirsch, Betriebswirtschaftslehre: Systeme/Entscheidungen/Methoden, 1973, p. 17
[53] See Ulrich, quote in: Bea/Dichtl/Schweitzer, Allgemeine Betriebswirtschaftslehre, 1993 , p. 86
[54] See FHI, Systeme und dynamische Systembildungsprozesse (project report), Stuttgart 1994, p. 36

by technological and functional relationships differs from a module in that the module is marked by the physical cohesion of sub-systems and the interchangeability of the entire unit in addition to having functional relationships.

Even SCHUSTER[55], former Member of the Board responsible for Design at VW, tended to treat the terms very flexibly. He described them as follows: *"We refer to something as a system or module if it is a subassembly that can be defined spatially and/or functionally in a meaningful fashion. The overall module process turned over to the system suppliers consists of designing, procuring, producing, assembling and delivering these units at their own responsibility...".*

In the paper, SCHINDELE[56] demonstrates impressively that there is no concise use of the terms among carmakers or suppliers. At DaimlerChrysler's (Stuttgart), for example, there are no modules. Ford uses the term 'module' frequently when referring to electrical parts. VW uses 'system' as meaning the integration of modules in a functional unit (VW differentiates between assembly modules, function modules and design modules), and at Porsche, there is generally no concise delineation of the terms.

Using the points depicted in the above as a basis, we find that:

- There is a clear definition of the term system in accordance with the theory of systems;
- There is a focus on the term 'system (direct) supplier' in the future. Potential functional or physical classification of procurement units is of secondary importance;
- Use of the term 'module' is not uniform.

The author is using the following definition as a basis[57] (see Figure 3.2) in the investigation of system building and the analysis by segment. Here, the term segmentation or the segmentation scenario, as applicable, presumes a product, vehicle, subdivided into systems, sub-systems and components:

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[55] See Schuster, H., Module Development, in: Automobil Entwicklung, Nov. 1995, pp. 40-44

[56] See Schindele, S., Entwicklungs - and Prozeßverbünde in der deutschen Automobil- und Zulieferindustrie unter der Berücksichtigung des Systemgedankens, PhD thesis, Shaker publishing, Aachen, 1996, pp. 84-92

[57] See also Schulte-Hillen, Scienctific Consult, Restrukturierungstrends in der deutschen Automobilindustrie im internationalen Vergleich, report for the office of economy, March 1995, p. 106

System: An arrangement of sub-systems and components defined by the carmaker that are interrelated and able to perform the functional and physical tasks demanded by the manufacturer.

When considering the investigation of system-building and the definition of the procurement units assigned to direct suppliers, which form the primary focus of this paper, the fact that these units are split up in accordance with the approach commonly used in current practice with no regard to functional delimitation or physical delimitation is of subordinate significance. This holds true all the more so when taking into account the fact that no uniform classification (system, module) exists among the OEMs. Therefore, based on the scientific definitions of terms presented in the foregoing, the term, 'System', must be viewed as a generally applicable super-ordinate term that is independent of any purely functional/technological assignment to groups.

Sub-system: Sub-units consisting of components that are needed to build systems. The functional or, as applicable, physical tasks and limits depend on the system.

Components: Units consisting of simple parts - standard parts, special individual parts, etc. needed to build sub-systems.

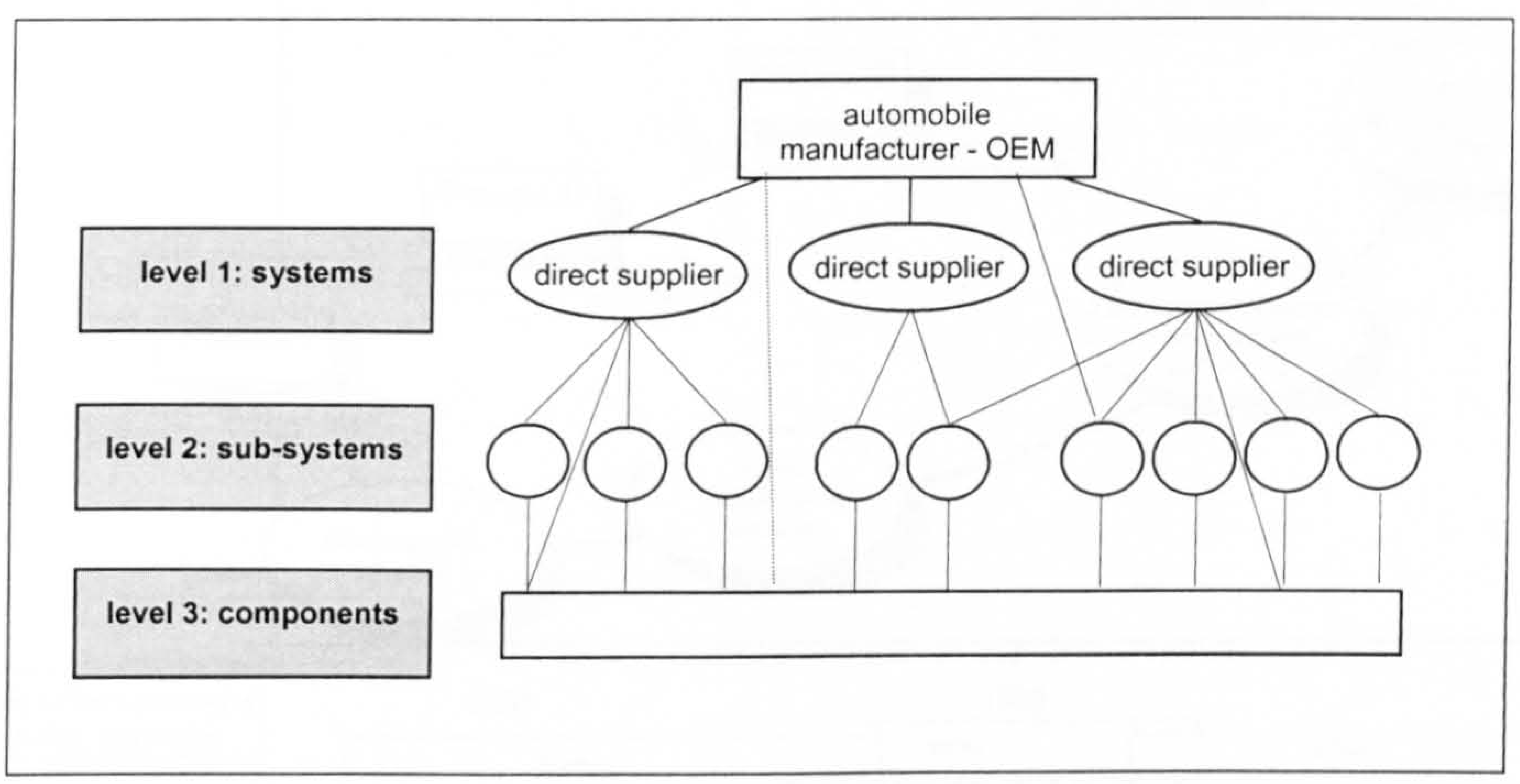

Figure 3.2: Classification of the supplier levels

Chapter Four: The automobile industry

This section presents various facts and figures to which the specific changes described in subsequent chapters can be attributed in part with a view to understanding the changes and phases of the automobile industry (Point 4.1.1) and the mechanisms that initiate the processes of change (Point 4.1.2) more fully. The core statements of the MIT study are also discussed briefly, as they are considered to be among the initiating factors of the entire wave of change (Point 4.2).

4.1 General remarks and an overview of the automobile industry

4.1.1 Different phases in the automobile industry

The investigation aimed at depicting the various phases of development in the branch of industry being considered here in general terms and characterising the various phases of development. LAMMING provides a deeper insight into this subject and a description of automotive developments since 1900 in his book "Die Zukunft der Zulieferindustrie[58]" ("The future of the supplier industry").

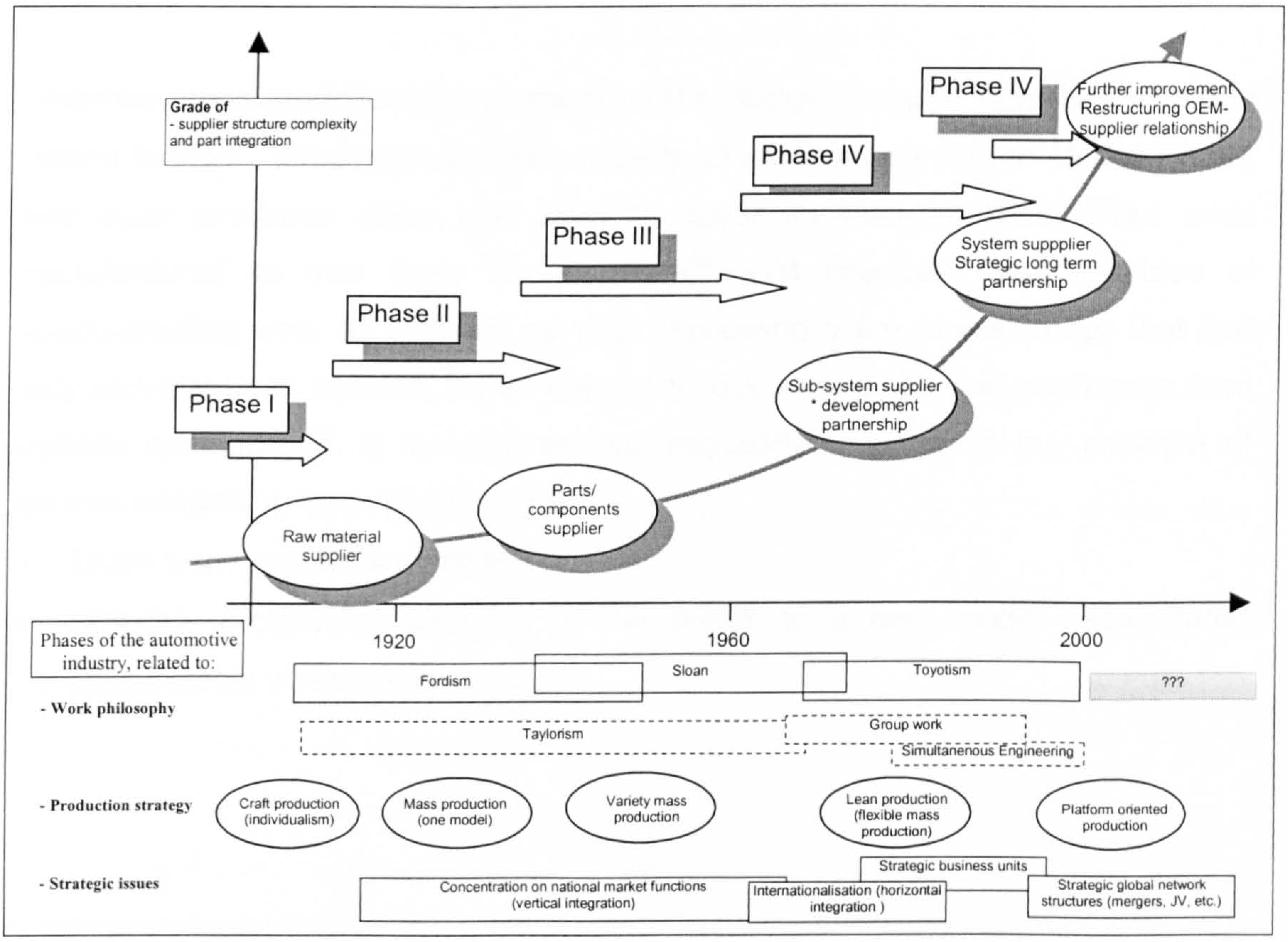

Figure 4.1: Different phases in the automobile industry

Phase I (craft production) was characterised by the following:

- Vehicles were manufactured by hand, and every vehicle had its own specific features; production was rich in variants and diversified
- Very low production volume
- Low organisational complexity, high transparency
- Low degree of standardisation of working processes
- Few defined quality controls, every worker checked his own work and rectified problems as necessary
- Share of team work was low

Phase II (mass production, one model):

- High degree of standardisation of working processes (Taylorism: Division of tasks into small, manageable, easily performed steps)
- Narrow qualification, specialisation was in demand (Taylorism)
- Dense sequence of quality controls
- High vertical integration, car manufacturers produced virtually everything themselves

Chandler made the following comment on the Rouge Complex created by Ford in Detroit in 1927. *"Ford manufactures virtually all components for the Model T here, and even produces glass and steel to cover its own needs..."*. Ford even manufactured its own tyres for 10 years[59]. GM chanced upon the idea of subcontracting work as far back as 1901. Following a fire in workshops that had only recently been opened, it was obliged to buy in engines and gearboxes from outside companies[60]. It nevertheless subsequently reverted to the principle of vertical integration as applied by Ford.

- Team work was not important.
- Inflexible production; changes or the switch to a new model necessitated considerable investment.

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[58] See Lamming, R., Die Zukunft der Zulieferindustrie: Strategien der Zusammenarbeit, Lean supply als Überlebungskonzept, Campus publishing, Frankfurt, 1993

[59] See Chandler, A. (editor), Giant Enterprise: Ford, General Motors, and the Automobile Industry, Harcourt Brace and World publishing, New York, 1964

[60] See Abernathy, W.J., The Productivity Dilemma: Roadblock to Innovation in the Automobile Industry, 1978

Phase III (variety mass production):

- Mass production was characterised by greater flexibility, and the production of different versions became possible (greater customer orientation)
- Reduction of vertical integration; many components were now bought in; emergence of the supply industry
- Development work was already being contracted out to a small extent
- Degree of specialisation remained high in all areas (production personnel, design, engineering)
- Rise in number of variants and increasing complexity necessitated considerable co-ordination
- Large number of production buffer zones and high storage capacity

Phase IV (lean production, Toyotism[61]):

- This phase was dominated by Japanese car manufacturers and the implementation of new, more efficient methods
- Workers were integrated into teams
- Responsibility was delegated, faults were rectified at the point of detection
- Procurement departments became larger and more complex
- Few production buffer zones and little storage capacity by virtue of intelligent steering of production and logistics operations
- Increasing number of variants and models (in response to individual market needs)
- Earlier integration of suppliers into the development process (although the USA and Western Europe were still deficient in this respect)
- Increasing delegation of tasks to suppliers
- There was still not much attention being devoted to optimising the entire value chain (development and production)

Phase V (further improvements):

- Consideration of the entire value-added chain
- Suppliers regarded as partners
- Emphasis on integrating suppliers rather than simply using them
- Trust-based partnership

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[61] See Jones, D.T., Beyond the Toyota Production System: The Era of Lean Production, conference paper, Warwick, June 26/27, 1990

- Improvement of the interdisciplinary and inter-institutional exchange and management of information
- Implementation of a small number of platforms for a maximum number of vehicle concepts and classes[62].

4.1.2 The main factors having an impact on the automobile industry

Economic success of the automotive supply sector depends to a very great extent on growth rates in automobile production (see Figure 4.2[63]). The European car industry enjoyed a string of record years for sales up to 1990, with the tide turning from 1990/91. This trend was particularly marked in Germany, where the sales boom persisted until 1993/94 as a result of the special effects of unification on the economy. Whereas this flourishing market and the favourable Dollar exchange rate[64] concealed the shortcomings of European manufacturers compared to their Japanese competitors (MIT study), sales fell sharply between 1990 and 1993.

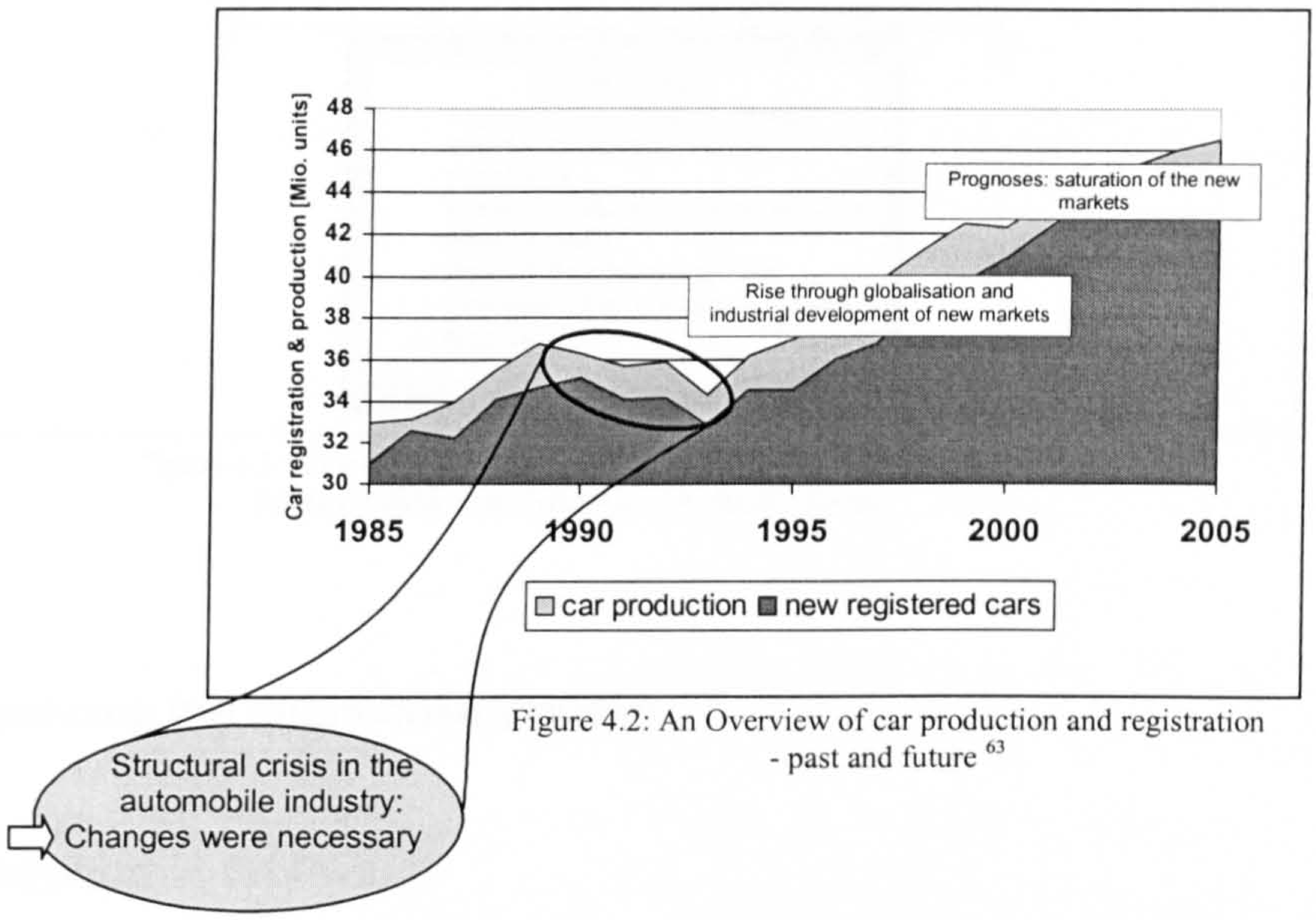

Figure 4.2: An Overview of car production and registration - past and future [63]

The increasing number of foreign competitors, the excess capacity that had been built up in the past and increasing criticism of individual transport from an ecological perspective forced manufacturers to effect strategic and structural

[62] See also Trott, G., It's all Rover Now, in: Manager Magazin, January 1997 edition, p. 58
[63] In Automobil Produktion, Oct. 1996, p. 10, source: Marketing Systems, Essen
[64] The Dollar exchange rate fall off by approx. 50 % compared to the DM after 1985.

changes. Figure 4.3 provides an overview of the principal factors and effects influencing the automobile and supply industries, which are then discussed later.

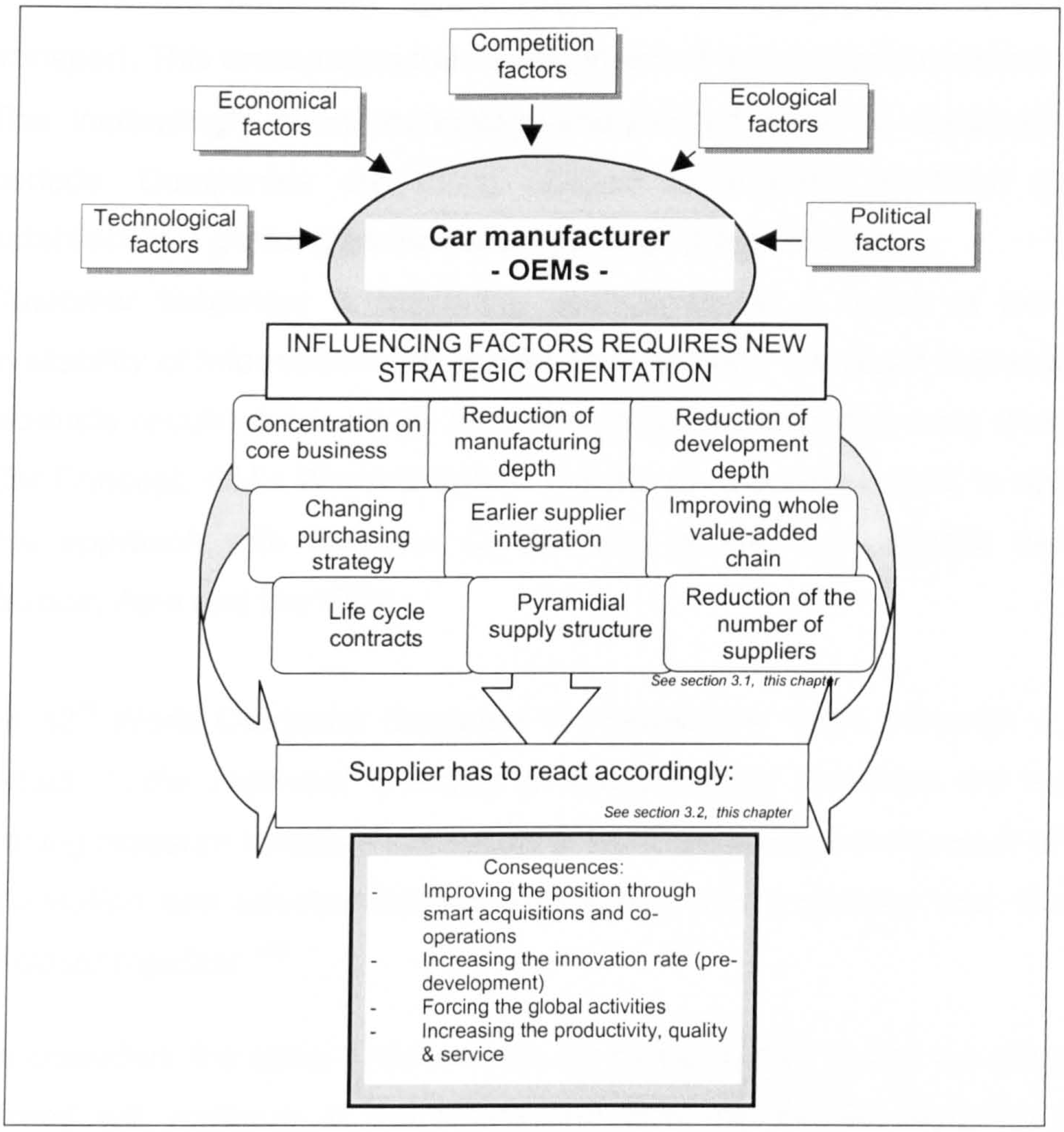

Figure 4.3: An overview of the main factors and effects influencing the automobile manufacturing and supply industry

Factors influencing the automobile industry.

Important economic factors:

The influence of economic factors is characterised particularly by the trend toward globalisation in the automobile industry and the formation of new economic regions. The causes of globalisation can be defined roughly as follows:

- As a result of changes in political direction, many countries are shifting from a traditional protectionist economic policy to a liberal one, and are thus becoming part of the global market.
- Information engineering and communications technology are overcoming the boundaries between markets. This development is particularly marked in the

capital, money and stock markets. Decisions are being communicated in real time, wherever they are made, and implemented immediately.

- Products are becoming lighter and more complex, thus facilitating their transport. This encourages the development of a global procurement system.
- The increasingly short technology-and-product cycle is reducing pay-back periods. Companies are being obliged to shorten pay-back periods by establishing a global presence and opening up new markets.
- Customer behaviour is becoming assimilated as a result of the universal availability of information and communication, with the result that standardised products require increasingly less adaptation to national trends (Ford's World Car Concept, GM's World Engine). Toyota, on the other hand, is not adopting this approach with the new Corolla and is creating different versions for Europe, Asia and the USA.

At the 13th World Computer Congress in Hamburg in 1994, Heinrich v. PIERER remarked: *"...the high-cost locations in industrialised countries are exposed to increasing pressure because the nature of work will change as a result of progress in information and communications technology, and countries and markets will grow closer together."*[65]

If one considers the basic requirements for globalisation, it can be assumed that this trend will continue in the future and that automobile manufacturers and suppliers will have to follow it. This process does not simply offer advantages; it also harbours risks in the guise of the major investments which will have to be made in production and development sites. Examples from the recent past reveal that particular importance is attached to improving global emphasis. BMW has erected a new plant in Spartenburg (USA), as has Mercedes-Benz in Tuscaloosa (USA) and Brazil and Audi in Brazil. VW is considering erecting a plant in the USA; Hyundai wants to build a plant with an annual capacity of 100,000 units in Bristol (UK); Japanese manufacturers – Toyota, Nissan, Honda, Mitsubishi - want to double their European production capacity to over 1 million units[66]; Honda is planning to produce 30,000 vehicles a year in China together with Dongfeng from 1999 on and Ssangyong is planning a production plant in Hungary, etc..

[65] See Wuppertaler Kreis e.V., Internationalisierung – Chancen und Risiken für die Zulieferindustrie, Forschungsbericht, Deutscher Wirtschaftsdienst, Vol. 46
[66] See w.A., Automobil Produktion, Aug. 1997, p. 9

Exchange rates form another significant factor. This is a highly influential parameter that can cause outstanding achievements and strategies to fail and can mask entrepreneurial inability, particularly when it comes to export nations.

Fig. 4.4 shows the development in the exchange rates of the Yen/$ and the DM/$. If one considers the figures soberly, it becomes apparent that the strength of the Dollar against the Deutschmark, for example, more or less automatically boosted sales revenues/profits of automobile manufacturers exporting to the dollar region (USA) for the period 1982 to 1986. At that time, sales and profits were good and there was no binding need for structural or organisational changes or for the introduction of productivity-enhancing programmes, etc. The effect of this lethargy and of a passive attitude over a number of years became all the more serious with the emergence of Japanese competitors, whose market share gradually rose. It was also aggravated by the absence of return on capital as the exchange rate fell. Now that American and Western European manufacturers have re-established their productivity and profitability as a result of drastic restructuring measures, Japanese automobile manufacturers are in turn confronted with this phenomenon, with the yen recently (from `96 until mid `98) experiencing a dramatic slump in value.

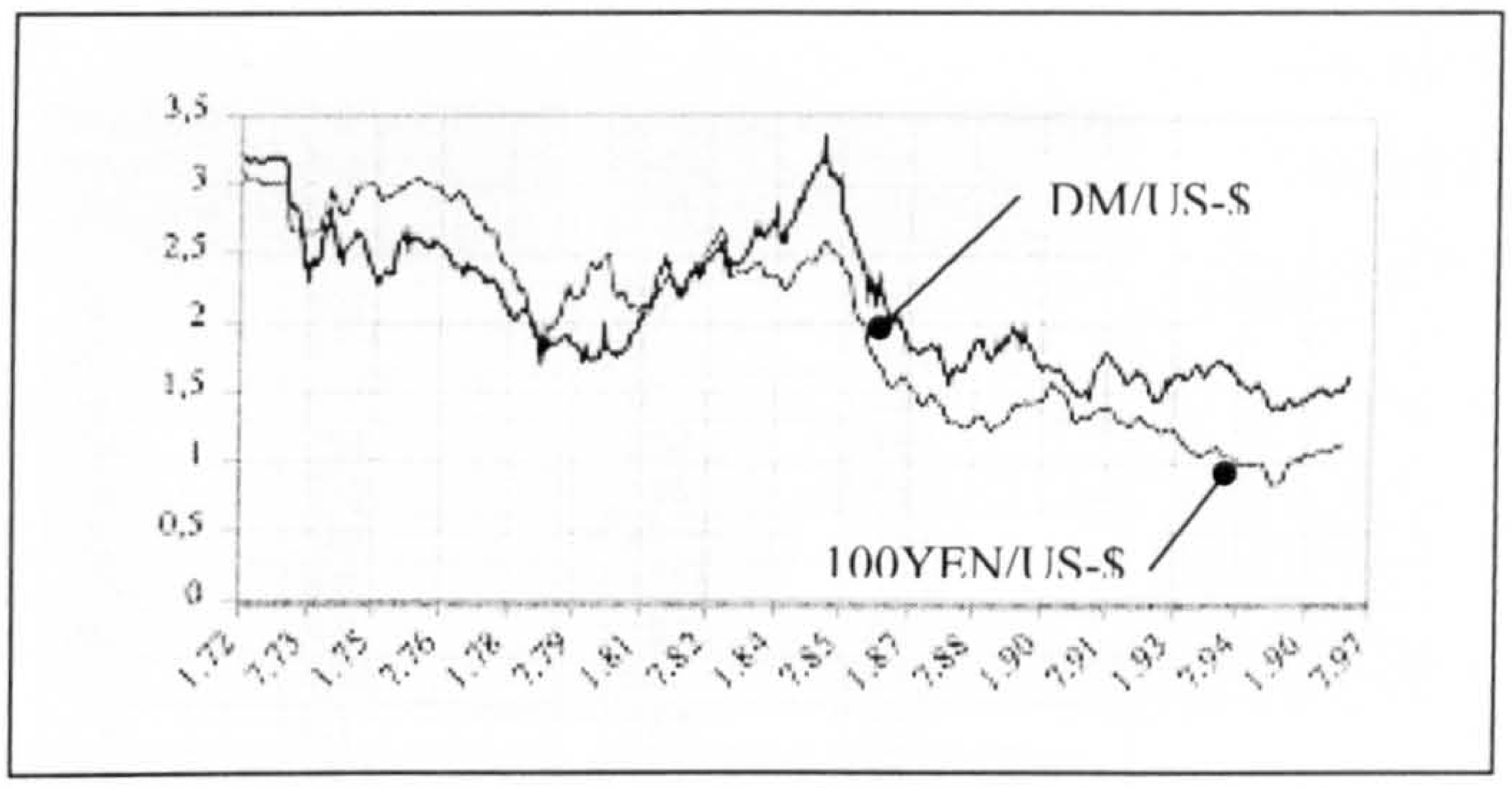

Figure 4.4: Currency trends (source: Standard & Poors DRI, Division of McGraw-Hill, World Automotive Forecast Update, 1997)

A further aspect:

Marketing experts and strategic experts often use the level of industrialisation of the country in question, the level and development of the GDP per inhabitant and GDI as their basis for planning[67]. Particularly the development in real income in the various national economies is a very useful indicator of potential sales, as has already been verified by studies on the correlation between per capita income and car density[68]. According to Boston Consulting, three percent of the 280 million households (= 8.2 million) in China were earning $ 4000 in 1995. For Asia as a

[67] See ifo-Institut (institute for economic research), Pkw-Verkehr in Europa bis zum Jahr 2005, 32/1996, p. 10 and VDA, International Auto Statistic, edition 1988, 1993, 1995

[68] See Brown, S., DRI/McGraw-Hill World Car Forecast conference, London, Nov. 1995 and AAMA Motor vehicle, Facts & Figures `93 & `96

whole (excluding Japan), the figure was around 40 million. According to the experts, a threshold income of $ 4000 is sufficient to be able to afford a small car. The total number of households in this bracket could be as high as 190 million by 2003. There is consequently an immense number of potential customers for the automobile industry, even if aspects such as the existing infrastructure, the energy supply and the environmental situation should not be overlooked in this connection and have a very strong influence on the situation.

Country	Inhabitants 1991 [mil. people]	Car density 1991 [cars/1000 inhabitants]	Inhabitants 1996 [mil. people]	Car density 1996 [cars/1000 inhabitants]	Inhabitants 2003 [mil. people]	Car density 2003 [cars/1000 inhabitants]
France	56	509	58	522	59	534
Great Britain	55	476	58	477	61	479
Germany	79	510	83	521	87	532
USA	248	757	265	754	283	752
Japan	124	483	125	532	126	587
South Korea	43	98	45	186	47	352
China	1151	5,3	1210	8,6	1270	13,9
India	886	5,3	952	6,9	1023	9,0
Philippines	65	9,4	74	10,5	84	11,7
Pakistan	117	7,8	129	8,1	142	8,3
Indonesia	193	15,5	206	18,1	221	21,2
Argentina	32	178	34	170	36	162
Mexico	90	118	95	126	101	135
Brazil	148	89	162	93	178	97,4

Table 4.1: Development of car density[67, 68]

Table 4.1 indicates the development of car density between 1991 and 1996 as well as the prognoses for 2003 and highlights the untapped market potential in countries with a large population such as China, India, Indonesia, Mexico and Brazil etc. when we compare their numbers with those of industrialised nations.

Technological factors:

A distinction must be made here between process technology, information technology and product technology. Access to key technologies/pacemaker technologies[69] on the one hand and further development, long-term preservation and utilisation on the other form the key factors here. In principle, one can state that it a company must assume a pioneering and innovator (formerly imitator[70]) role in order to secure a leading competitive position and future market share[71], despite the greater risk and investment volume involved.

When taking a look at the history of the automobile industry, we find that innovation in various areas has always brought about a competitive edge. Henry

[69] See Braess, H., Technologieführerschaft der europäischen Automobilindustrie, in: Meinig, W. (editor), Wertschöpfungskette Automobilwirtschaft, Gabler publishing, Wiesbaden, 1994

[70] See Lamming, R., Die Zukunft der Zulieferindustrie, 1993, p. 114

[71] See Wildemann, H., Optimierung von Entwicklungszeiten: Just-in-Time in Forschung & Entwicklung und Konstruktion, 1993, pp. 239-240

Ford's success, for example, was based on the introduction of a new process technology, the assembly line. Toyota's success was based on the innovative achievements of the just-in-time system, the lean production and management philosophies, and Audi exploited its technological advantages in the field of four-wheel drive, vehicle aerodynamics, the aluminium vehicle body and TDI technology (diesel direct injection) to increase its market share.

In the light of increasingly demanding expectations from end customers and legislative bodies with respect to safety, comfort, economy and reduced pollutant emissions, car manufacturers will not be able to get around the installation of further systems, particularly electronic and mechatronic systems[72], in their vehicles. Up to 90 % of all new features in new models are already based on electronics[73].

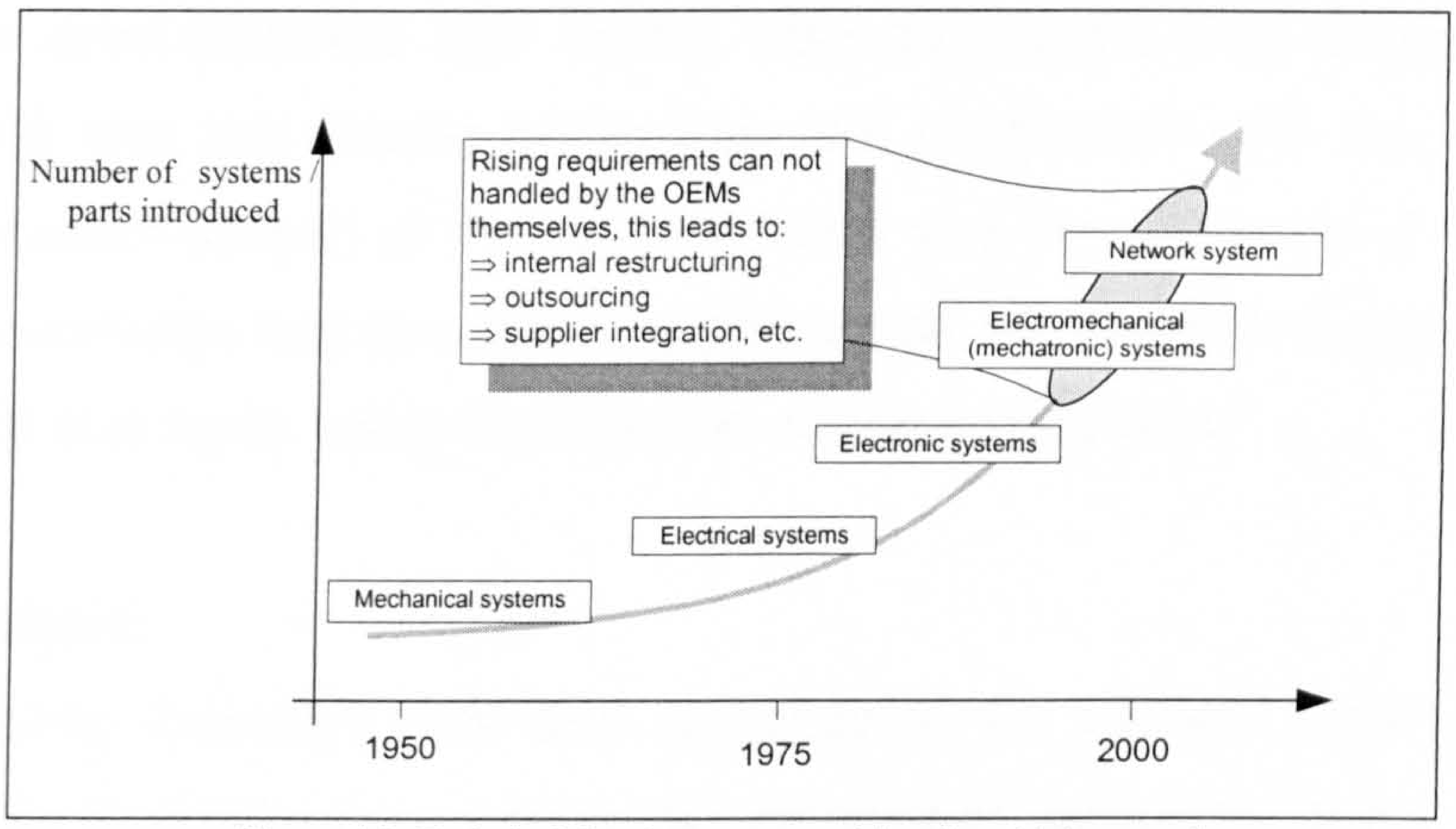

Figure 4.5: Technical developments resulting from higher requirements

This challenge and the pressure on manufacturers to innovate are intensified by the sharp reduction in the development time available and in product innovation life cycles. The qualitative representation below results when one considers the increase in requirements in the course of time (safety, comfort, environmental requirements, etc.) and extrapolates the plotted curve for systems launched per time unit.

This harbours the risk that sales/profits may suddenly plummet when new products are brought onto the market at increasingly shorter intervals (Figure 4.6). As the relationship between innovation costs, pay-back periods and time to

[72] See Selze, H. (editor), Der Startschuß ist gefallen, in: Automobil Elektrik, August, 1997, p. 18
[73] See Automobil Produktion, April 1998, p. 62

product maturity is no longer tenable, we find we are in an "*acceleration trap*", to use the name given this phenomenon by Braun, who verified it by simulation[74].

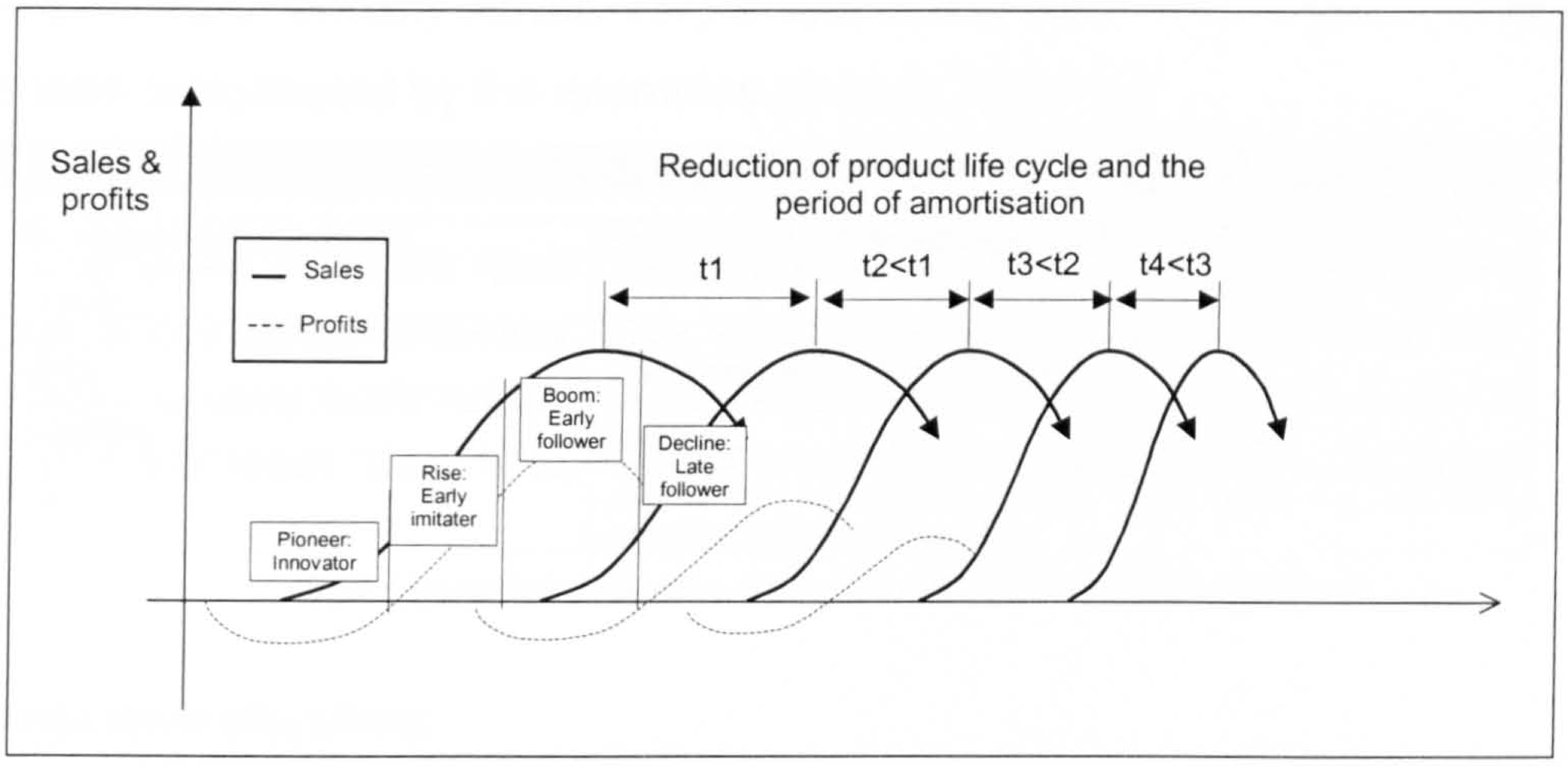

Figure 4.6: Sales, profits and the product life cycle

Automobile manufacturers are hardly able to handle this sharp increase in requirements and the diverse tasks they are confronted with on their own any longer. A broader spread of the tasks in hand and the utilisation of expertise and specialist knowledge that already exist elsewhere are needed in order to adhere to the time and cost limits being imposed on development work.

Political factors:

The automobile industry's size and significance for various national economies make it highly dependent on political developments, although, at the same time, it is able to exercise a limited amount of influence. In their home countries, automobile manufacturers are subject to political trends and legislative changes, which may have favourable or unfavourable effects on any given situation.

The variable factors include:

Safety legislation, recycling legislation, motor vehicle taxation, insurance classifications, environmental regulations, consumer tax, traffic restrictions and import/export regulations.

A detailed discussion of these individual variables would transcend the scope of this paper, and their respective impact would need to be analysed in detail on a case-by-case basis. As a general rule, it can be stated that Japan tends toward a

[74] See Braun von, C.F., The Acceleration Trap in the Real World, in: Sloan Management Review, Summer 1991, pp. 43-50

role of promoter, supporter and developer (through the MITI)[75] while the USA acts purely as the legislator and Western Europe is shifting from the role of proprietor (Renault, PSA, formerly Rover, VW) to that of legislator. The impact of regulations and laws is illustrated by the examples given in Table 4.2

Regulations	Effect
Zero Emission Regulation (USA)	Forces the OEMs to develop zero-emission vehicle
Law for returning and recycling vehicles (Germany)	Automobile manufacturer have to build up the appropriate infrastructure
OBD II (on board diagnosis) regulation (USA, started)	Engine control units have to be designed in order to fulfil those requirements, means more R & D efforts
Regulation for catalytic converter (Germany, started 1986)	Automobile industry was forced to introduce catalytic converters in all vehicles
Euro IV Norm (Western Europe, starting 1999)	Regulation for limiting emission; new vehicles have to be designed correctly from the beginning, those models which are already in production have to be re-designed

Table 4.2: Regulations and laws (source: Emission `99, handbook Mercedes Benz)

Competitive situation:

Market saturation tendencies coupled with continuing or increasing levels of excess capacity have led to the emergence of new automobile manufacturers (e.g. Proton, Ssangyong), the liberalisation of markets and the start of globalisation[76] and the intensity and pressure of competition have increased quite considerably. Table 4.3 and Figure 4.7 provide a brief insight into the changes in global automobile production and the export/import situation in the Triad markets. The globalisation tendencies of Japanese automobile manufacturers since 1985 are clearly identifiable.

	Production volume (cars)				Western Europe			US + Canada			Japan			Korea		
	1975	1989	1996		1975	1989	1996	1975	1989	1996	1975	1989	1995	1975	1989	1995
Western Europe	9345	13710	13708	Exports to				706	379	n.i.	26	143	236	n.i.	n.i.	n.i.
US + Canada	7775	7807	7359	Exports to	16	49	n.i.				17	20	133	n.i.	n.i.	3
Japan	4568	9052	7863	Exports to	383	1439	713	802	2218	1301				n.i.	n.i.	n.i.
Korea	n.i.	986	2264	Exports to	n.i.	n.i.	265	n.i.	n.i.	223	n.i.	n.i.	n.i.			

Table 4.3: Production, export and import of cars (in 1000 units)
(source: DRI and VDA[79])

Whereas the Japanese manufacturers strove to satisfy the world-wide increase in demand from their production sites at home

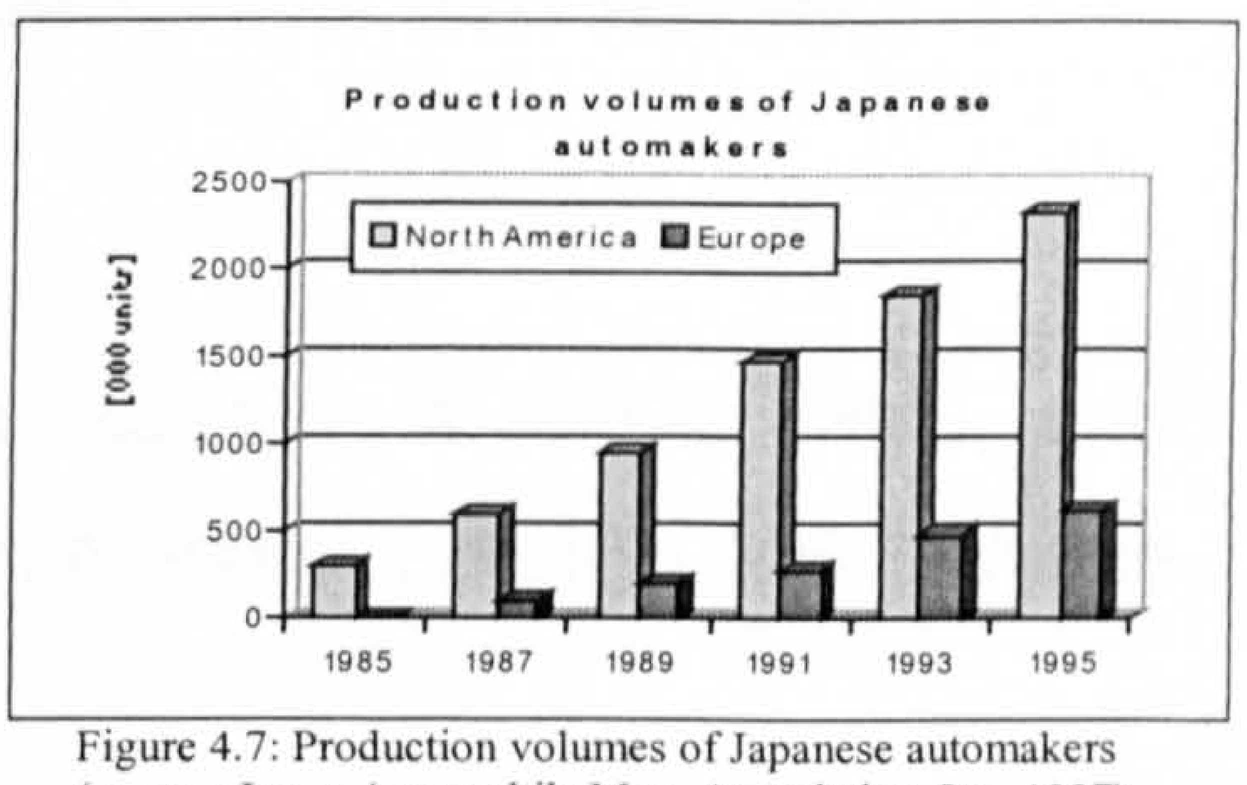

Figure 4.7: Production volumes of Japanese automakers
(source: Japan Automobile Man. Association, Inc. 1997)

[75] MITI is the Ministry of International Trade & Industry. The ministry provides financial support for research and development in technical areas which have been identified as strategically important.

[76] Yip, G.S., Global Strategy….In a World of Nations?, in: Sloan Management Review, Fall 1989, pp. 29-40. In his article, Yale gives a detailed framework for evaluating whether – and how – to globalise an individual firm's corporate strategy. He describes the opportunities for gaining competitive advantage and provides examples of companies who have exploited globalisation drivers and strategy levers.

in the early 1980s, they subsequently switched to the approach of satisfying increased demand through "transplants" - production sites in the country of sale - resulting in more intense competition for the automobile manufacturers in the countries in question.

This strategy, together with the resulting proximity to the market and its particularities, helped the local population to identify better with the product and accept it more readily.

Customers are subscribing more than ever before to the finding of the OHMAE: "They all want the best product available, at the lowest price possible"[78]. As a result of the continuing liberalisation of markets, the modification or lifting of any restrictions and barriers which still exist (import restrictions, local content, import duties) is progressing (see for instance Table 4.4), with the result that an increase in predatory competition is to be expected.

South Africa:	Stepwise lowering of import taxes for FBUs (fully built-up) vehicles based on GATT requirement taking into consideration the increase in local manufacturer preparation from 115% in 1994 to 50% in 2003.
Poland:	Lowering of import taxes for vehicles from 30% in 1995 to 0% in 2002
Czech Rep / Slovenia:	Lower of import taxes for vehicles from 11.4% in 1995 to 0% in 2002
Hungary:	Lowering of import taxes for vehicles from 11.7% in 1995 to 0% in 2002
Russia:	Lowering of import taxes for vehicles from 15% in 1995 to 0% in 2002
Australia	Lowering of import taxes from 131% in 1980 to 5% in 2010

Table 4.4: Examples of changing regulations and trade tariffs [79]

Until now, these hindrances were circumvented by taking recourse to SKD (semi-knocked down) and CKD (completely knocked down) production methods.

Ecological factors:

Awareness of ecological matters has changed radically in recent years, and society's general sensitivity to the issue of environmental pollution has become much more acute.

[78] See Ohmae, K., The Global Logic of Strategic Alliances, 1989, pp. 143-154

[79] see VDA, International Auto Statistics, VDA Frankfurt, 1988, 1993, 1997; and, World Car Industry Forecast Report, Standord & Poor's DRI, Division of MacGraw-Hill, Feb. 1998

The automobile industry has come in for increasing criticism, for instance due to the fact that all the registered cars and commercial vehicles in the world (of which there are over 600 million) together[80] generate over 2 billion tons of carbon dioxide[81]. Pressure on the automobile industry to keep in line with this environmental awareness through innovations – new engine concepts, the use of sustainable raw materials, weight-saving design, intelligent materials, new vehicle concepts for ease of recycling, etc. – is becoming ever greater, necessitating increasing research and development expenditure and increasingly complex systems.

Fiat's head, G. Agnelli, once said: *"You can't be greener than your purse."*[82]

The environmental discussion in the automobile industry focuses on three basic areas: a) exhaust/pollutant emissions, b) energy consumption and c) recycling. It can be assumed that legal requirements will become increasingly stringent in all three areas. On top of this, resources are becoming more and more limited while the world-wide vehicle population and with it, over-all energy consumption continue to grow. This development will actually be encouraged by industrial nations' striving for annual economic growth and the emergence of "threshold" countries.

4.2 The MIT Study

Reactions to The MIT Study, its boundary conditions and its findings are discussed in a separate section due to the study's special status in the automobile industry and its significance.

The book, "The Machine That Changed the World", is regarded as essential reading for every manager in the car sector. The study, known for short as the "International Motor Vehicle Program (IMVP)" and led by the Massachusetts Institute of Technology (MIT) between 1985 and 1990, is considered the most extensive of its kind in that it considers the efficiency of the automobile industry in the Triad markets - USA, Japan and Western Europe. 36 internationally spread organisations and institutions (renowned automobile manufacturers, suppliers, automotive associations and registration offices) sponsored this programme to the tune of 5 million Dollars. The study was able to identify six critical elements

[80] See Facts and Figures '93, AAMA Motor Vehicle, yearbook, 1993, p. 39
[81] See Vester, F., Ausfahrt Zukunft, Strategien für den Verkehr von morgen, Munich, 1990, p. 15
[82] See Agnelli, G. Giovanni Agnelli über Fiat, die Japaner und die Grünen, 1989, pp. 99-102

(comprehensiveness of vision, specialist knowledge, globalality, independence, industrial access and ongoing feedback).

The "International Motor Vehicle Program" bore the following characteristics:

- Participation of universities from the USA, Europe and Japan
- Participation of research experts in the business sector from various different countries
- Division of the study into sub-areas (production, development, supplier system, technology, customers), in each of which a team of specialists conducted detailed investigations at universities and in companies.
- Annual meetings attended by all research members
- Annual international presentations of research findings, to obtain feedback from decision-makers at the various organisations (automobile manufacturers, suppliers, governments, federations)

The research findings are published in the above-mentioned book by WOMACK/JONES/ROOS[83]. This work presents only the principal findings and therefore only a selection of the articles written by the IMVP researchers, which appeared in over 150 publications. It nevertheless clearly pinpoints the advantages of the Japanese automobile industry over its US and European counterparts, and identifies the causes and reasons for this. Some of the principal advantages and reasons are indicated below.

Advantages of Japanese automobile manufacturers (with Japan as the country of manufacture) compared with European manufacturers (with Europe as the place of manufacture):

Quality:
- Japanese manufacturers' vehicle quality (assembly defects per 100 vehicles) is around 60% better compared with European manuf. (level: Japanese manuf. 60 defects/100 vehicles)
- After launching a new model, the Japanese reach normal quality standards after 1.4 months; the Europeans take 12 months.
- The number of training hours for new production workers is twice as high at Japanese manufactuers' as at the Europeans ones'.

Supplier:
- Lead time for new dies is almost 4 times higher at European manufacturers'.
- The Japanese' changeover times are over 15 times better than the Europeans'.
- Japanese suppliers deliver to customers 8 times a day, European suppliers 0.7 times; whereas 45% of the parts from the Japanese suppliers are delivered JIT, the Europeans manage only 8%.
- Suppliers' share of engineering work at Japanese manufacturers' is 51%, and 32% at Europeans'.

[83] See Womack, J.P./Jones, D.T./Roos, D., The Machine That Changed The World, 1990, p. 92

Manufacturing:	Development:
- Productivity (measured in hours per vehicle): Japanese manufacturers (in Japan and North America) take 16 to 22 hours, European manufacturers take 36 hours per vehicle. - The required manufacturing space (sq.ft/vehicle/year): Japanese manufacturers approximately 5.7; European 7.8. - Similar situation regarding the necessary space for repairs (measured in % of manufacturing space): European manuf. requires 3.5 times more space than their Japanese competitors. - Japanese manuf. take 4 months to reach a normal productivity level after launching a new model. The European manuf. take12 months.	- European manuf. need on average 1.4 Million engineering hours more to develop a new vehicle than their Japanese competitors. - Despite this fact, they take 30% longer to prepare development. - The Japanese develop on average 2.3 different body styles per vehicle and the Europeans 1.3 in the same time. - The development time (measured in months): Japanese manuf.: 13.8; Europeans 28

The following aspects were identified as causes of the Japanese manufacturers' dominance:

- Utilisation of existing experience and know-how among suppliers through the increased level of development and production tasks being contracted out
- Co-ordination work for development and logistics is limited to a small number of direct suppliers
- Direct suppliers integrated at an early stage, to optimise the value-added chain
- Application of "Kaizen" continuous enhancement in small steps
- Avoidance of "Muda" (= waste) in all areas through intelligent development, production and delivery methods (JIT, Simultaneous Engineering, pull instead of push principle)
- Integration of individual workers into teams, and delegation of more responsibility to lower levels of hierarchy in order to boost motivation and commitment

The emphatic nature of these findings, which clearly pinpointed the situation of the European and American automobile industry, in conjunction with the increasingly acute factors governing the automobile industry, obliged the manufacturers concerned to respond rapidly in an effort to optimise their efficiency and innovative capability, and to raise their motivation and readiness to change and adapt in order to be competitive. Particularly among automotive suppliers, a process of fundamental structural change was and still is taking place; this will exercise considerable influence on the relationship between manufacturer and supplier.

4.3 Consequences for the automobile industry and the changes made so far

4.3.1 Consequences for automobile manufacturers

The described processes of change as a result of the principal influencing factors and the dynamic process to which every branch of industry is exposed - and which is particularly marked in the automobile industry - exercise considerable influence on automobile manufacturers, necessitating adaptation in a wide range of respects. Some of these aspects, particularly those which are especially significant to automotive suppliers, are listed and discussed below.

4.3.1.1 Acquisitions and alliances

By way of introduction, here are a few general comments on the terms 'acquisition' and 'alliance'. Strategic alliances with other companies differ primarily in terms of the degree of capital involvement (minority/majority interest), autonomy and inter-organisational connectivity[84].

There are various reasons for making acquisitions or entering into alliances (Table 4.5).

Reasons for acquisitions and alliances:
- Establishing a quasi-monopoly in order to alleviate pressure from competition
- Exploiting market strength in order to exhaust the scope for price increases
- Optimising economy of scale
- Compensating for own weaknesses
- Obtaining better access to new markets, patents, technologies, otherwise unavailable resources and expertise
- Influencing and compensating for risk segments and factors
- Improving economy of scope
- Exploiting synergy benefits, spreading fixed costs over a greater product base
- Exploiting/creating ways of reducing the tax burden
- Improving access to the money and capital market

Table 4.5: Reasons for acquisitions and alliances

Every company that is striving to obtain a controlling interest over or collaborate with a partner has the objective of securing certain advantages through its actions, in order to improve its market position and therefore, its sales and profits. Figure 4.8 and Table 4.6 show trends in the numbers of strategic alliances through acquisitions and alliances.

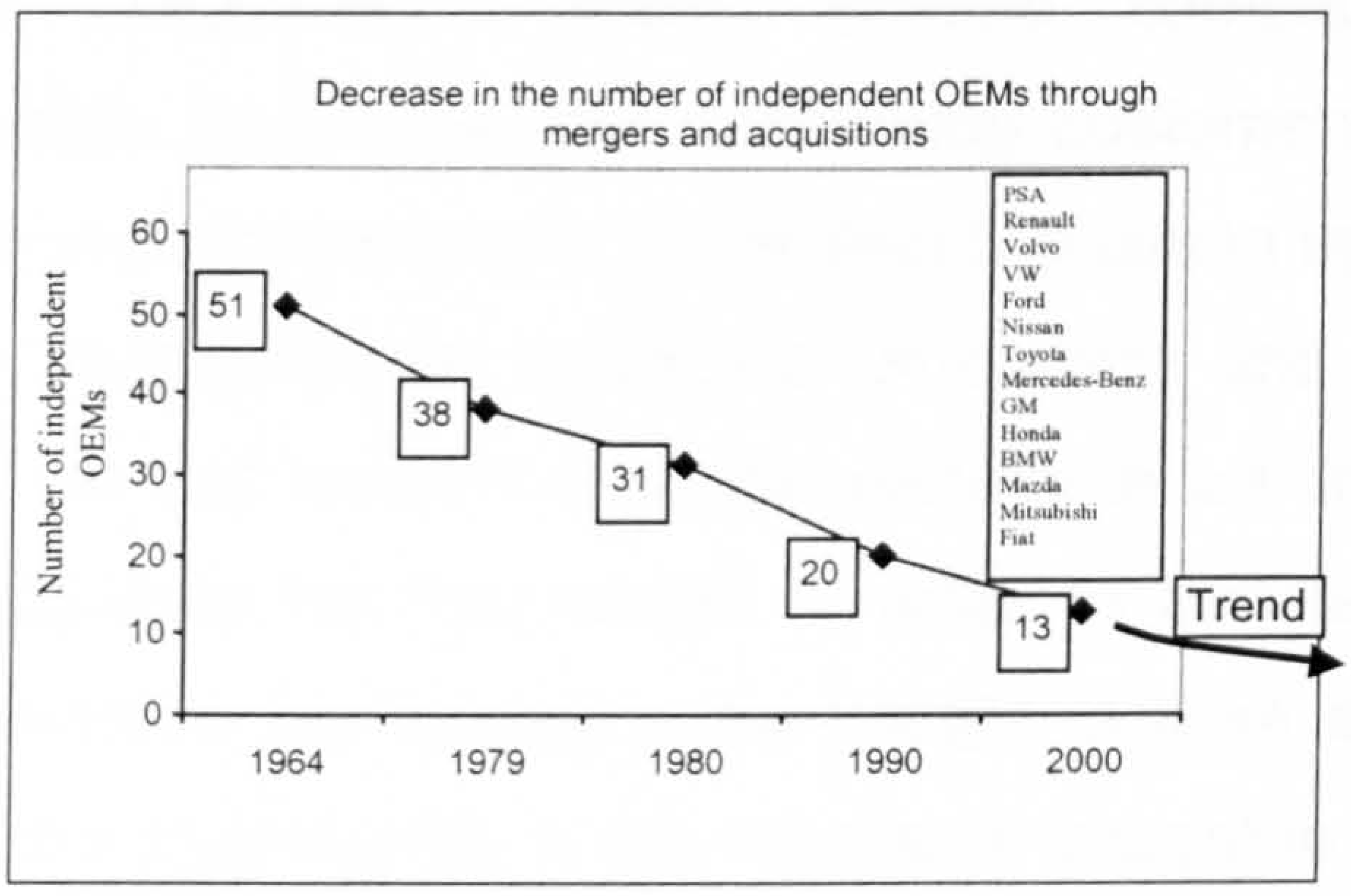

Figure 4.8: Development in the constellation of automobile manufacturer[85]

Examples of acquisitions since 1982:

VW: Take-over of Seat and Skoda
GM: Saab and Lotus
Chrysler: Lamborghini (sold to Audi 2000)
Ford: Jaguar, Austin Martin, LandRover, Volvo
Fiat: Ferrari, Lancia and Alfa Romeo
Daewoo: Ssangyong
Peugeot: The remaining 47% of Citroen
BMW: Rover (sold again 2000)
VW take-over of Rolls-Royce (Bentley)
Current merger of Daimler-Benz and Chrysler

Examples of alliances since 1982:

VW and Renault: Automatic gearbox (development and production
DC (former DB) and Mitsubishi: Light vehicle trucks (development & production)
GM and Toyota: Founded NUMMI
Chrysler and Mitsubishi: Founded Diamond Star Motors
VW and Ford: Founded Autolatina and Autoeuropa
VW and Toyota: Pick-up truck production
BMW and Chrysler: Small engines (development and production

Table 4.6: Examples of acquisitions and alliances

The number of independently operating automobile manufacturers, of which there were 51 in 1964, will have fallen to around 13 by 2000[85]. This process of corporate consolidation is clearly increasing and will be felt by suppliers, who will be confronted with a situation where their business i.e. sales will depend on fewer but larger customers. According to a detailed investigation by Henkel[86], automobile manufacturers' forging of inter-organisational alliances with other manufacturers – in the form of joint ventures, or collaborations with or without capital involvement – increased by more than 300 % between 1980 and 1989. We can expect this trend to continue[87] in view of increasing internationalisation, integrative tendencies among suppliers and in products and the market activities observed.

4.3.1.2 Depth of manufacturing and development

Taking into account the strategies devised on the basis of corporate objectives/visions, the efficient use of the available resources (personnel, facilities,

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[84] See Gutberlet, T./Hohberger, P./Schreiner, P., Kooperation in der Kfz-Zulieferindustrie, Investigation report, Diebold Consultant, Eschborn, 1995; and, Killing, J.P., Understanding Alliances, 1988, pp. 55-67
[85] See Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, 1993, p. 21
[86] See Henkel, C.B., Akquisition und Kooperation als strategische Alternative aus Sicht der deutschen Automobilindustrie, PhD thesis, St. Gallen, 1992, pp.38 ff..; also, Schindele, S., 1996, pp. 117, 129 ff..
[87] A good overview of the automobile manufacturer relationship can also be found in the journal Automobil Produktion, in: Automobil Produktion, overview, 1997

technology, patents, etc.) is of critical importance with reference to the forthcoming changes.

The ever-shorter cycle of innovation[88] and product life, a rapid increase in model diversity (explosion in model variants, complexity) to satisfy the needs of increasingly discerning and demanding customers, and the need to maintain an international presence are all constantly pushing up the level of resources required (higher staffing levels, additional production and development units, etc.). This, despite the fact that the available resources are limited by the inter-structural and inter-organisational framework. In order to handle the volume of work required, more services are having to be bought in from external providers. As a rule of thumb, the progression in the volume of bought-in services is linear to changes in the relevant parameters (cycle of innovation, model diversity, globalisation). According to the defined core competence[89] principle (product, technology) of "doing what you can do best" and differentiating one's products from those of competitors, the internal depth of manufacture and development is being cut back and these tasks are being sub-contracted to suppliers. In his investigation, WILDEMANN reached the conclusion that German automobile manufacturers trimmed their manufacturing depth by 10% - 20% between 1987 and 1995[90]. This finding is confirmed by WÜTHRICH and WINTER[91].

On the basis of a benchmarking study, WOLTERS reveals how the development depth of European manufacturers will decrease over the period 1993 to 2000. He identifies a clear shift from in-house development to external development[92]. Winterkorn, former Member of the Board for Development at VW, considers it ideal when outsourced development work makes up 20 - 30% of total development costs. The figure for the development of the new Passat was 50%, a level that was too high for VW[93]. On the basis of statements made by various manufacturers, SCHINDELE forecasts that the level of work contracted out to suppliers, excluding the manufacturer's core development work, will change as follows:

"Advanced development:	*Currently 10%*	*In future 80-90%*
Project definition:	*Currently 0%*	*In future 10%*

[88] See Rotering, C., Forschungs- und Entwicklungskooperationen zwischen Unternehmen, 1990, p. 2
[89] See Hamel, G./Prahalad, C.K., The core competence of the corporation, 1990, pp. 79-91
[90] See Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, 1993, p. 48; also Femerling, C./Eicke von, H., Modular Sourcing, 1991, p. 9; and, Wolters, H., Produktion wird verlagert, in: FAZ, 17.09.1996
[91] See Wüthrich, H.A./Winter, W.B., in: Management Zeitschrift, 1996, p. 62
[92] See Wolters, H., Mehr Systeme, in: Automobil Produktion, April 1994, pp. 38-39; Wildemann, H., 1993, p. 32; Wolters, H., Customer Integration; and, Füll, G., Automobilbauer übertragen immer mehr auf Systemlieferanten, in: Handelsblatt, No. 48, 1995, p. 35
[93] See Winterkorn, M. (Interview), Wir haben zu wenig Systemlieferanten, in: Automobil Produktion, Oct. 1996, pp. 32-33

Series development: Currently 20% In future 90%"[94]

As the reasons for outsourcing will gain even more influence, albeit not at the current rate, a continuing increase in suppliers' volume of production and development is to be expected. Procurement departments at automobile manufacturers and their procurement strategies will become increasingly important as a result. Every Deutschmark saved on the purchase price means an extra Deutschmark profit, without any additional resources being consumed.

In Figure 4.9 shows a diagrammatic represent of the situation.

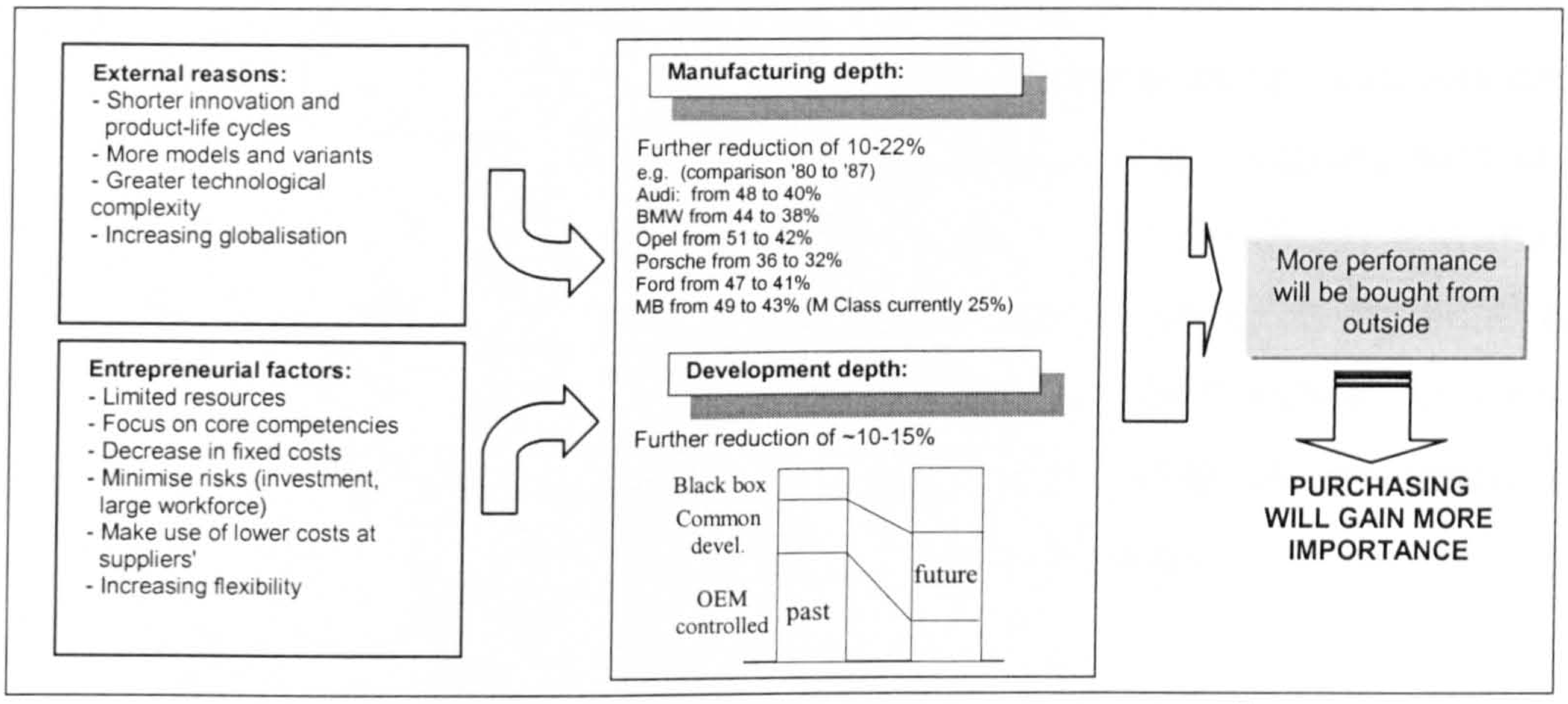

Figure 4.9: Impacts on depth of manufacturing and development [90]

4.3.1.3 Purchasing strategies

Along with the increasing division of labour between different countries, the cost structures of companies have changed dramatically over recent decades. The average cost of materials and bought-in services for industrial companies in the USA has, for example, risen from 20% of sales to 56%[95], an almost three-fold increase. Depending on the respective branch, material costs as a proportion of sales range from less than 40% in the service sector to over 85% in the oil industry, for instance. As procurement activities account for the largest pool of costs over which direct influence can be exercised, they play an important role in determining a company's financial success at a time of falling returns. Much like sales activities, they also act as a link between the company's requirements (e.g.

[94] See Schindele, S., 1996, p. 121

[95] See Keough, M., "Buying your way to the top", in: The McKinsey Quarterly, 3/1993, pp. 41-52; Bhote criticised the miss ratio of the cost situation between manufacturing cost and material cost compared to the allocated management resources., 50% of management resources are dedicated to manufacturing, which presently represents 5% of the sales volume. Only 5% of management resources are dedicated, compared to material costs, which represent 50% of the sales volume; See, Bhote, K.R., Strategic Supply Management – A Blueprint for Revitalising the Manufacturing-Supplier Partnership, New York, 1989

development and design specifications, production needs, quality management requirements) and external requirements. Despite the enormous scope for exercising influence, procurement was unable to break free from a very narrow outlook dictated by operational policies and strategies for a long time. It is only recently that a change from isolated, polarised disposition activities to procurement and supply management has taken place.

There is no longer room for the traditional tactical purchasing of parts from the supplier on the basis of predefined development results in an industry where issues such as time, costs, complexity and quality are becoming increasingly pressing. The direct influence of procurement on entrepreneurial success can be illustrated by the following brief example. If, for example, a company with annual sales of DM 100 million, a profit-sales ratio of 6% (= DM 6 million) and material costs of 50% of total sales (= DM 50 million) succeeds in cutting its materials costs by only 4%, it would boost its profits by DM 2 million to DM 8 million, an increase of 33.3 %. In order to achieve this increase in profits through increased sales revenue, the company would have to boost sales by one-third.

Various methods are used to optimise the situation and tap potential for savings, as it has transpired that rigid approaches to suppliers do not pay off for the manufacturer in the medium and long terms. In addition to single sourcing, global sourcing, forward sourcing and modular sourcing[96], which are described in greater detail below, supplier integration in conjunction with the fundamental reduction in the number of suppliers[97] is one of the key means by which automobile manufacturers can enhance their competitiveness. The more efficiently value-added chains can be integrated[98], the more successful a partnership between the manufacturer and its suppliers will be, and this is the very basis on which market position can be improved. Almost all automobile manufacturers have launched special schemes to this end (see Table 4.7).

[96] See Meinhold, M., Die Automobilzulieferindustrie im Umbruch, 1995

[97] Based on published investigated results, the supplier base at the OEMs' will be reduced on average by 200-300%; see w.A., Zulieferzahl: weniger Direktkontakte, in: Automobil Produktion, June 1995, p. 8, source: Mira-Report; Lamming, R., 1994, p.234; and Esebeck, G. von/Reif, R./Struwe, C., Supplier co-operation: a way of becoming a system supplier in the automotive industry, conference paper, 29th Isata, Proc: Mechatronic-Advanced Development, 1996, pp. 429-436

Programme	Manufacturer	Main focus	Expected cost reduction[99]
Tandem (start 1992)	Daimler-Benz (now DaimlerChrysler)	Earlier and more intensive supplier integration, fair co-operation, more support and higher efficiency	30-40%
DFL [Drive For Leadership, start 1992]	Ford	Building interdisciplinary teams (OEM-supplier) in order to localise and eliminate weak spots	>40%
PICOS [Purchased Input Concept Optimisation with Supplier, start 1991]	Opel	Joint workshops with suppliers; localising and eliminating barriers in order to increase efficiency	Max. 50%
POZ [Prozess Optimierung Lieferanten (Process Optimisation Supplier), start 1992]	BMW	Building interdisciplinary teams for: quality management, integration and motivation of employees, customer and production oriented	20-30%
KVP [Kontinuierlicher Verbesserungs Prozess (Continuous Optimisation Process) start 1993]	Audi, VW	Common workshops and creativity teams in order to increase customer value and reduce waste	30-50%
P.O.L.E Position (start 1884	Porsche	Process optimisation through supplier integration and continuous improvement process	20-50%
n.i.	Volvo	n.i.	n.i.
n.i.	Sogedac	n.i.	n.i.
n.i.	Renault	n.i.	n.i.

Table 4.7 : Special programmes of OEMs [99]

Previous improvement programmes by OEMs in both the European and North American automobile industries have focused primarily on stages further along the value-added chain than procurement[100]. Procurement activities have received little attention in strategy programmes, or have been conducted independently of the entire supply chain, even though bought-in materials account for some 45% of the price paid by the customer of a European vehicle model. There is immense potential for joint improvement here.

Co-operation between automobile manufacturers and suppliers primarily takes the form of rearward-focused, vertical value-creation partnerships. This form of co-operation as shown in Figure 4.10 - the value-added chain - is thus gaining importance precisely in those areas in which the manufacturer is unable to use existing or in-house concepts, and must instead perform complex and extensive development work, whether of a basic or more advanced nature. The optimum dovetailing of the relevant departments, early integration of the supplier and optimum availability and distribution of information are essential if efficiency is to receive the necessary boost.

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[98] See Porter, M.E., How information gives you competitive advantage, 1991, pp. 34-37
[99] See Automobil Produktion, Dec. 1996, p. 62
[100] See Cohen, M./Griffiths. S.T., Strategic Sourcing – The Key to Competitive Advantage, in: EIU International Motor Business, No. 140, Oct. 1998, pp. 75-96

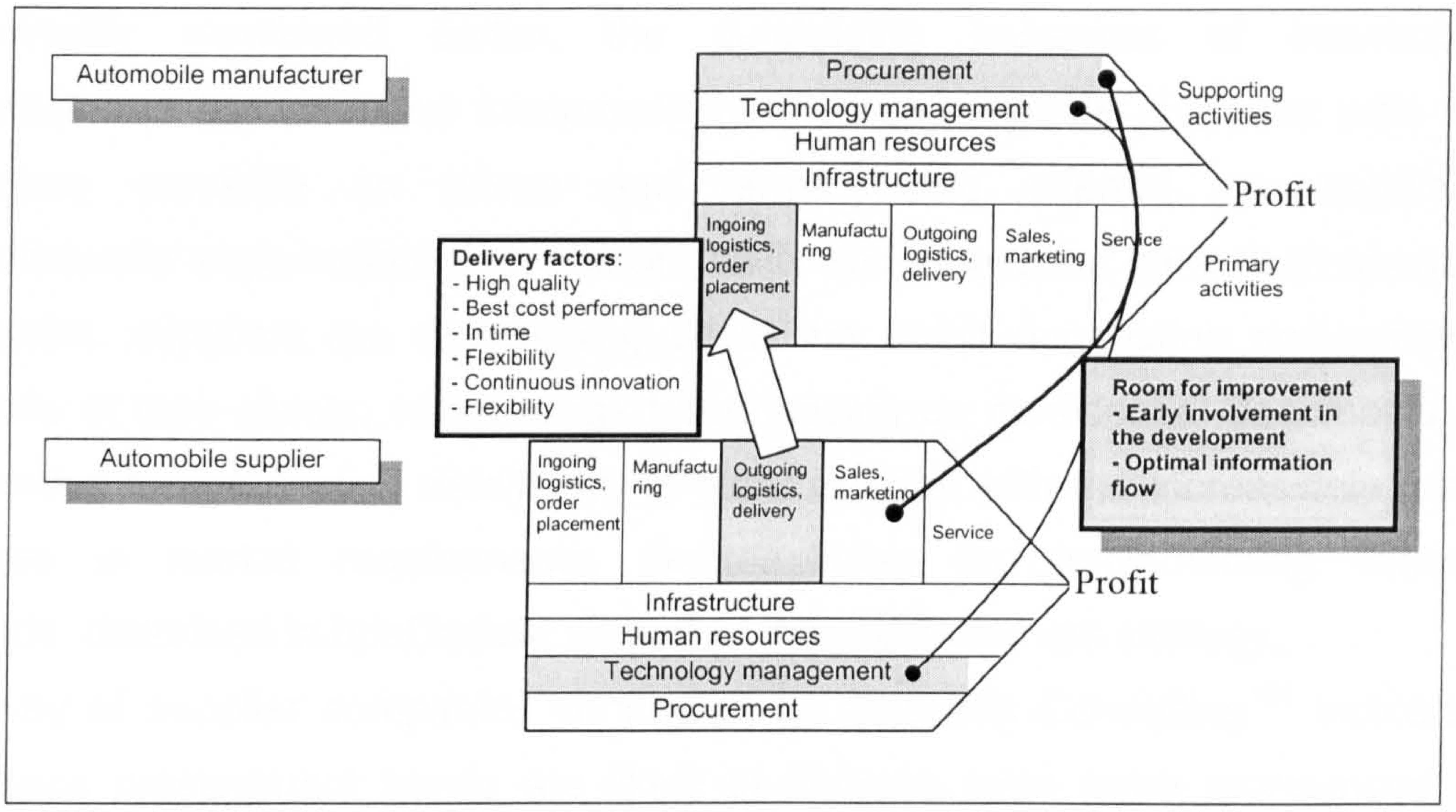

Figure 4.10: The value-added chain, requirements and room for improvement[101]

In addition to analysing the individual activities for the scope of differentiation and cost minimisation they offer, according to the two fundamental strategic thrusts described by PORTER[101], the value-added chain is also a suitable means of investigating intra-company and inter-company interfaces precisely. If there are interdependencies and synergies at the interfaces, the activities in question in the value-added chain can be combined or eliminated[102]. The need to safeguard long-term market and competitive success is obliging companies to focus all value-creation activities on those critical strategic areas where they will be more successful than their competitors. As the pressure of competition intensifies, it is becoming increasingly important to excel in the decisive criteria, and to secure a leading position in certain areas. It is no longer simply a question of taking up a position at the right point along the chain and performing the right value-creating activities; value has to be produced hand in hand with suppliers, sub-contractors, business partners and customers throughout the entire system of the value creation. NORMAN and RAMIREZ, for example, perceive the core task of a strategy *"as the systematic planning of joint innovations, through the ongoing development of complex business systems"* [103]. This view is nothing new; rather, it represents a systematic progression from PORTER's call to link the company's

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[101] See Porter, M.E., Competitive Advantage - Creating and Sustaining Superior Performance, New York, London, 1985
[102] See Hägeli, S.W., Just-in-Time: Ein strategisches Erfolgspotential, in: Krulis-Randa, J.S./Hägeli, St.W., Megatrends als Herausforderung für das Logistik-Management, Bern, Stuttgart, 1992, pp. 181-214
[103] See Norman, R./Ramirez, R., Werte schaffen mit Kunden und Lieferanten, in: Harvard Business Manager, 1/1994, pp. 53-64

value chain with that of suppliers, sales channels and customers to produce a comprehensive, efficient value system.

As already mentioned earlier, the purchasing behaviour of automobile manufacturers has changed fundamentally in some respects. Together with the enormous pressure on prices and terms being exerted on suppliers, manufacturers' expectations in terms of quality and innovation have risen sharply. In parallel, suppliers are complaining about the unfair negotiating and working methods of their clients, which range from passing on confidential documents to demanding to see costing details. In an effort to cope with the increasingly rapid changes in market requirements, manufacturers are implementing various methods, described in brief below, as part of their procurement strategy.

A survey of supplier companies conducted by Scientific Consulting[104] indicated that these procurement trends are likely to become even more pronounced in future. At a number of manufacturers, the single sourcing method has been less pronounced to date than the other strategies. This can be explained by the fact that car manufacturers are only willing to take the high risks associated with dependence on a single supplier to a limit and for very specific products.

Single sourcing: Procurement of a product from one supplier only

Effects: The automobile manufacturer reduces the number of external interfaces, thereby achieving savings. The risk for the OEM is greater, as it has no other options in the event of delivery difficulties. The positive effect on the supplier is the higher volume.

Global sourcing: Procurement activities and competition are world-wide.

Effects: The OEM's basis for comparison becomes broader. The supplier is confronted with more intense competition, particularly for products that have little innovative content and are labour-intensive.

Forward sourcing: Early integration of suppliers in the product development process (conception phase).

Effects: High potential for improving "time-to-market"; suppliers need to be pro-active[105].

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[104] See Scientific Consulting, Restrukturierungstrends in der deutschen Automobilindustrie im internationalen Vergleich, Dr. Schulte-Hillen BDU, March 1995

[105] See Lamming, R., Supplier strategies in the automotive components industry: Development toward lean production, 1992, p. 296

System/modular sourcing: The procurement of systems, with the supplier assuming overall responsibility.

Effects: The OEM can scale down its development and manufacturing depth, and deploy the resources now released for other tasks. In most cases, modular sourcing involves major adjustments for the supplier, potentially entailing high investments in addition to taking on a broader range of activities and responsibilities. Striving to become a module supplier is therefore not necessarily always the most advisable course of action. This trend among automobile manufacturers poses particular problems for mid-corporate suppliers.

4.3.2 Consequences for the supply industry

Sooner or later, automobile suppliers will feel the impact of these general macroeconomic changes and the resulting adjustments made by automobile manufacturers, which the author has attempted to sketch briefly in the above, along with the changing general context. They will be obliged to adapt to these changes as rapidly as possible if they are to maintain their competitive position.

Suppliers are undoubtedly dependent on the automobile manufacturers' output – visions, objectives, strategies and requirements – and are forced to adapt their own approach accordingly. Basically, they have the same tools at their disposal as the automobile manufacturers, the only difference being that the supplier is several degrees more dependent and that this restricts their entrepreneurial freedom of action.

The diagram below depicts the principal degrees of freedom in somewhat more tangible form starting with the core requirements.

With the future requirements and changes initiated by the manufacturers serving as the point of departure, the various options for placing the strategic and structural emphasis and for allocating resources need to be exercised in such a way that a company's own visions and objectives are achieved, and existing weaknesses in research and development, production, sales/marketing, logistics and purchasing are compensated for.

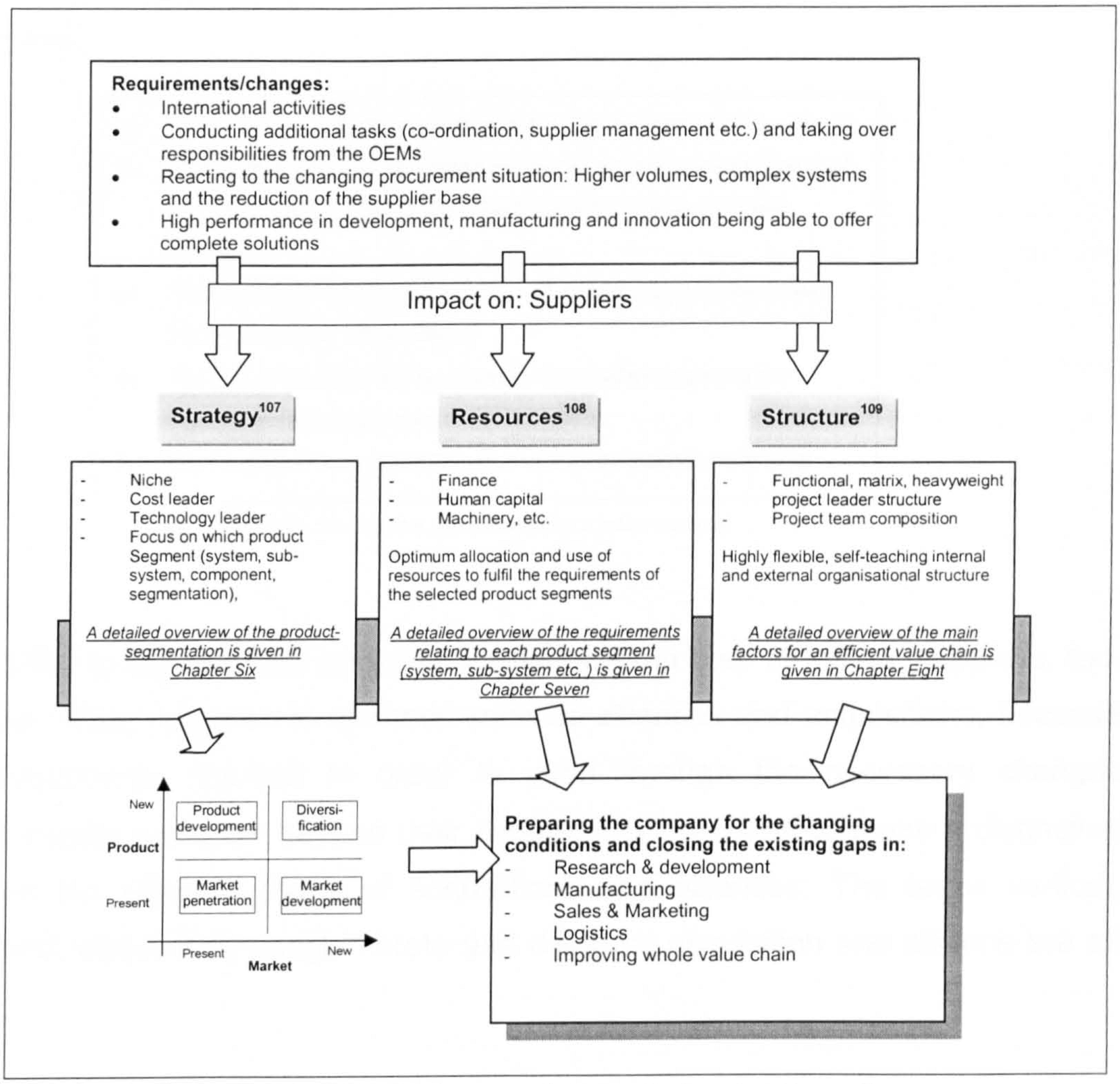

Figure 4.11: Requirements and changes affecting automotive supplier

More or less independently of the entrepreneurial emphasis of the supplier, the generally tougher requirements the supplier is having to meet are challenging it to optimise its strengths in order to establish a counterweight enabling it to act on an equal footing with car manufacturers[109]. These strengths, which did not hitherto exist in the form required in the individual sub-disciplines (research, development, production, procurement, sales/marketing), become necessary as a result of the changing supplier structure, as there is a demand for suppliers who are capable of offering total concepts (systems).

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[106] See Hinterhuber, H.H., Strategische Unternehmensführung, 1989, pp.17 ff.; Ansoff, H.I., Corporate strategy, 1965, pp. 109/128; and, regarding portfolio matrix see also, Porter, M.E. (editor), Globaler Wettbewerb, 1989, p. 32

[107] See Droege&Comp., Unternehmensorganisationen im internationalen Vergleich, 1995, pp. 24 ff.

[108] See Wildemann, H., Prozeß- und Leistungsbenchmarking als Instrument zur Potentialanalyse von Geschäftsprozessen, in: Prozeß- und Performance Benchmarking, conference paper, 1995, Munich, pp. 23-25

[109] See Porter, M.E., From Competitive Advantage to Corporate Strategy, in: Porter, M.E., On competition and strategy, 1991, pp. 15-32

By analogy to PORTER[110], the more the following conditions are met, the more an association of suppliers will be able to negotiate from a position of strength (Table 4.8).

a)	There are no substitute products for the package being offered
b)	The supplier hones its profile as a key problem-solver; product and logistics constitute important input for the automobile supplier
c)	The suppliers' share of the automobile industry's sales does not conceal any dependency
d)	The group of suppliers possesses key technologies upon which the OEMs depend
e)	The degree of concentration in the supply industry is higher

Table 4.8: Supplier requirements for a better standing

In an effort to compensate for these weaknesses in their make-up, suppliers, too, are now taking recourse to methods such as alliances and acquisitions, because the investments required in order to push through the necessary changes autonomously are often beyond their means. It is important to make a distinction between the different forms of acquisitions and alliances: The terms vertical, horizontal, concentric, conglomerate and diagonal acquisition and alliance are all used[111].

646 suppliers[112] generating 90% of their sales from the automobile industry were contacted and a response rate of 17% was achieved in a survey conducted in 1994 by FRASER, Organisation for corporate planning. The survey concluded that the readiness of the suppliers to enter into partnerships in order to handle the difficult situation will increase significantly. 90% of the companies which took part in the survey confirmed that they would be entering one or more co-operations over the next few years. Project-based alliances, joint ventures and collaborations with financial participation are given preference to licensing partnerships, alliances without financial participation and mergers[113]. SCHMOECKL/LIEBLER/ SCHINDELE confirmed this finding in their empirical survey conducted in 1995[114]. Examples of acquisitions and alliances between automobile suppliers can be

[110] See Porter, M.E., Wettbewerbsstrategie, Methoden zur Analyse von Branchen und Konkurrenten, 1987, pp. 54 ff.
[111] See Henkel, C., PhD thesis, 1992, pp. 48 ff.
[112] Investigation was concentrated on the German market
[113] See w.A., Wege aus der Krise, in: Automobil Produktion, June 1994, pp. 46-48
[114] See Schmöckl, D./Liebler, B./Schindele, S., Kooperationen zwischen Unternehmen der Automobilzulieferindustrie, VDI newspaper, Vol. 137, No. 5, 1995, pp. 36-38

found in such sources as WILDEMANN, HENKEL, the "Automobil Produktion" and "Automobil Industrie" trade journals in which a vivid choice of participations and take-overs from 1992 is shown[115].

4.4 Summary

This chapter aims to give the reader a condensed view of the changes, principal influencing factors and the current situation in the automobile industry. As an introduction, the characteristics of the four main phases of automotive development identified in terms of the relationship between the manufacturer and the supplier were analysed in detail and described. Along with the structural changes that have taken place since the emergence of the automobile industry, the supplier's position in relationship to the automobile manufacturer has shifted from that of a mere supplier of materials, through the intermediate stages of parts/components supplier and subsequently of sub-systems and development partner, to the system supplier and strategic development partner. Further interlinking of manufacturer and supplier activities, and in particular of activities between suppliers, can be predicted in response to the challenges of the future.
Other studies have concentrated on the main factors which influence developments in the automobile industry and their impact on manufacturers and suppliers. The focus of attention with regard to economic factors is on the trend toward globalisation, exchange rate developments and, importantly, the development in per capita GNP in the up-and-coming countries of Asia and South America. This latter aspect is interesting in that, an immense number of potential customers will find themselves in a position where they can afford a vehicle if real incomes increase simultaneously. It is expected that the number of households in Asia to reach the critical threshold income of $ 4000 will rise from a current 40 million to 190 million in 2003.

The technological aspects concentrate on the increasing complexity and shortening of product and innovation cycles and the developments in the field of automotive electronics. More stringent legislative requirements, prompted by a heightened awareness of environmental and safety issues, and changes in

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[115] See examples of acquisitions and co-operations, Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, 1993, p. 32; w.A. Konzentration in der Autozulieferbranche, in: FAZ, 27.10.1994, p. 23; Müller-Stewens, G./Gocke, A., Alone successful – together unbeatable, in: Automobil Entwicklung, March 1996, p. 94; Henkel, C., 1992; and, Peter, M., 1996; w.A., Der Markt frißt seine Akteure, in: Automobil Industrie, 1/1998, pp. 72-73

export/import regulations prompted by the global liberalisation of markets, also play a major role.

The International Motor Vehicle Program led by the MIT Study was what actually triggered off this far-reaching process of change and restructuring in the automobile industry. The study's findings yielded the reasons behind the overwhelming success of the Japanese in the 1980s and early 1990s.
New approaches to acquisitions and co-operations, a reduction in the depth of development and manufacturing and the implementation of new procurement methods were the logical consequences for American and European carmakers as they sought to keep pace with developments in an increasingly competitive environment. This is easily illustrated by a few basic facts: the number of independent automobile manufacturers has been more than halved since 1980, manufacturing depth has fallen from a previous 50 - 60% to as low as 30% and development work is increasingly being contracted out as a result of changes to development and supplier structures.

Suppliers, for their part, have constantly been obliged to respond to these changing boundary conditions. The changing supplier structure has meant that the strategy, structure and allocation of resources need adjusting in line with a company's objectives. Here, as in the case of manufacturer activities, suppliers are increasingly making acquisitions and entering into co-operations, in an effort to safeguard their chosen position within the supply pyramid and in order to equip them for the challenges of increasing product integration.

Chapter Five: Product integration - the trend toward systems/sub-systems/components

5.1 General perspectives

In 1970, there were only a handful of carmakers with a limited number of models competing globally. Today, competition among all carmakers has extended to include all internationally significant markets. Customers have become increasingly selective, sophisticated and demanding in the course of this development. Despite the declining rate of growth in the motor industry, the number of models has multiplied[116] and motor engineering has become increasingly complex and inhomogeneous. In 1970, for example, 80% of the vehicles manufactured in USA were equipped with a conventional V-8 engine, a three-speed automatic gear shift and rear-wheel drive. By comparison, customers already had 34 different variations to select from by the early 1980s. The resulting wide diversity of individual parts and components required for one vehicle mandated an enormously large number of direct suppliers (see Fig 5.1) when using the traditional supplier structure that had predominated until then as a reference.

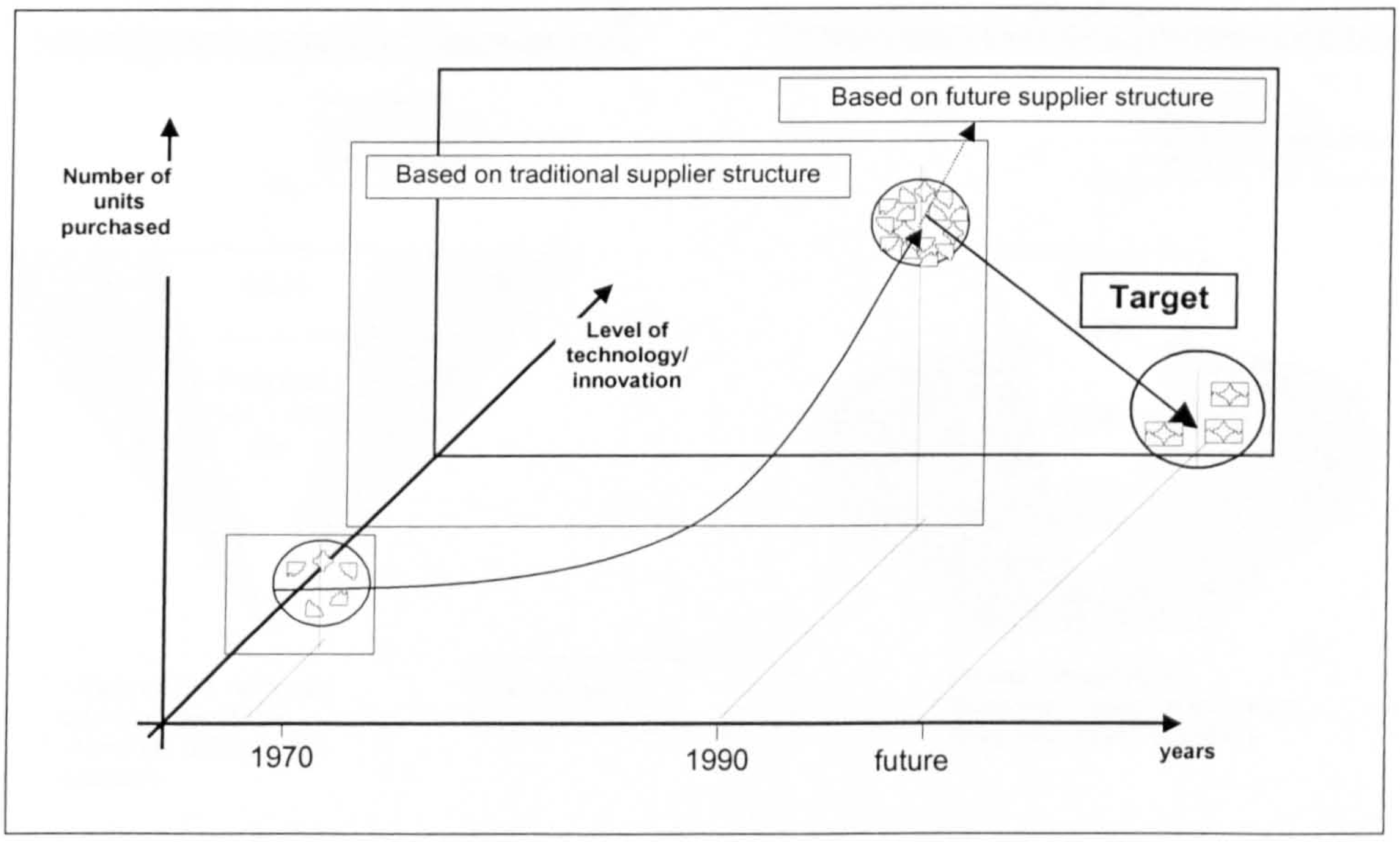

Figure 5.1: Increase in the number of units per vehicle

Under these conditions, manufacturers did not usually have only one supplier per component. Instead, they needed two or more to protect themselves against

[116] See Ehlers, K., Automobilelektronik – Start gelungen, wie geht es weiter? Strategische Überlegungen für die nächste Dekade, VDI-report, No. 612, 1986, p. 548

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supply bottlenecks. Any uniform product quality that was aspired could only be achieved by means of substantial testing and administrative work.

The arrival of ever new technologies (innovations) triggered by the demand for improved safety, comfort and environmental friendliness along with the increasing demand for more highly individualised products that had to be developed, and still have to be developed, in ever shorter intervals[117] has resulted in a virtual flood of technologies and models. For example, in 1992, there were already ten carmakers building cars comparable to the Mercedes S-Class in the North American market compared to only 4 competitors battling for market shares 15 years previously. VW plans to increase their number of models from 38 at the present to 51 in the next several years[118], for example. The former clearly defined boundaries of the procurement and industrial sectors (Figure 5.2) that served as a reference in the past are becoming increasingly blurred.

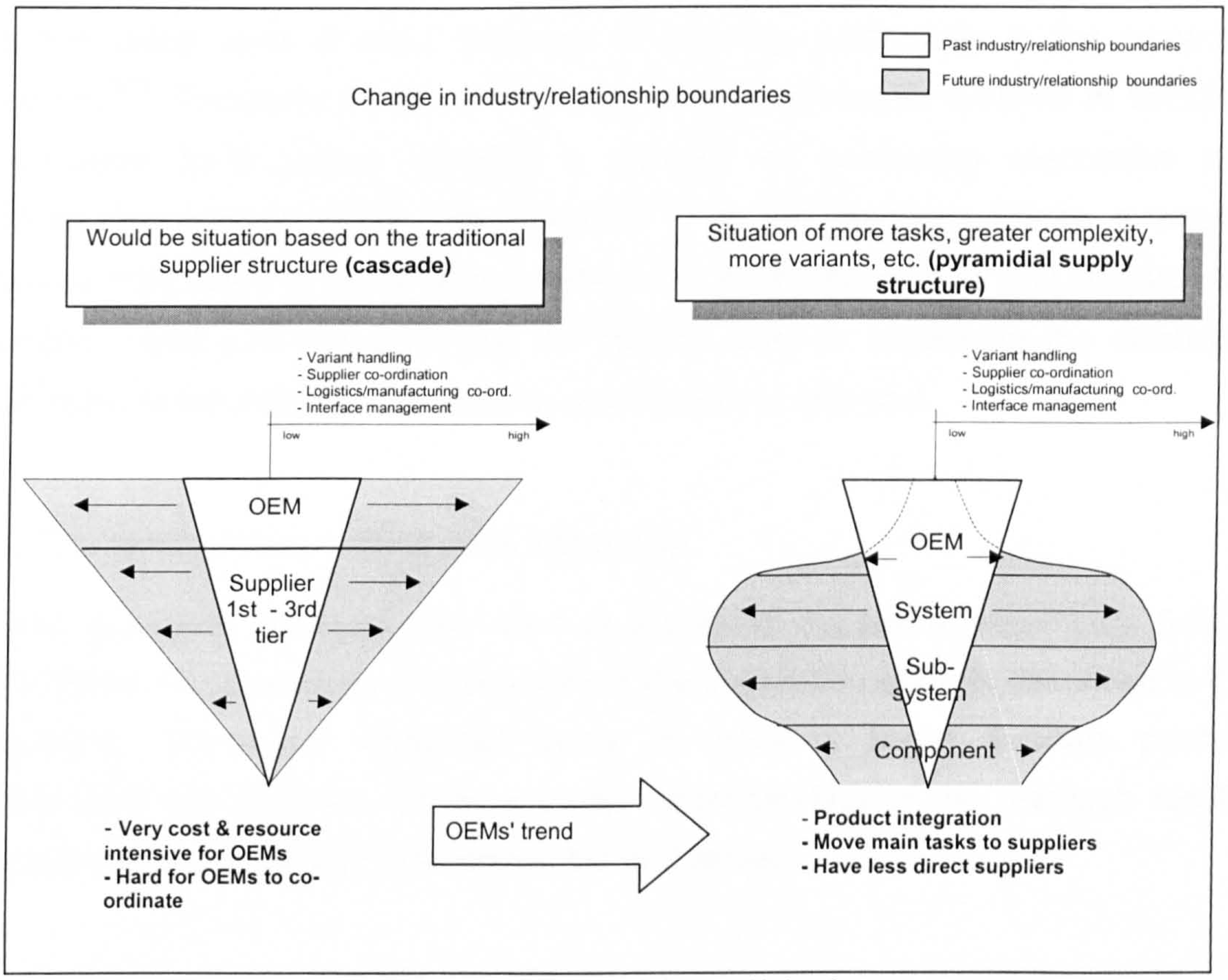

Figure 5.2: Changes in the industry and in interfaces

[117] See Staub, K., Die Unternehmenskooperation für Produktinnovation, 1976, p. 2; Krubasik, E.G., Kurze Entwicklungszeiten: Interne Studie der McKinsey & Company, Inc., 1986, pp. 81 ff.; and, Brockhoff, K./Urban, C., Die Beeinflussung der Entwicklungsdauer, in: Zeitschrift für betriebswirtschaftliche Forschung, No. 40, 1988

[118] See Pohlmann, A., Volles Rohr voraus, in: Manager Magazin, April 1998, p. 69

Manufacturers were forced to master numerous novel technologies and to translate these into products that were ready for the market within a minimum period of time in order to be able to keep step with increasingly keen competition[119]. All of this resulted in manufacturers departing from the traditional supplier structure and the division of labour and extending the depth of value creation to additional fields. They were put into a position where they had to deal with a larger number of suppliers. It was precisely this situation that turned out to be the cause of the weak competitive strength of European carmakers compared to the Japanese. Accordingly, they began searching for ways to remedy the situation and put themselves in a better position for dealing with the issues of rising costs and increasing time for development and co-ordination along with the increasing complexity of the vehicle systems.

The approach increasingly being used in the motor industry, namely that of integration in order to cope with the issues addressed in the above, is analogous to that being used in other branches of industry, particularly in the computer industry[120]. Pressured by the increasing share of electronic systems in vehicles, carmakers have begun applying a concept of combining mechanics and electronics referred to as "mechatronics"[121] in the literature. Some examples include integration of the engine control in the air intake module and coupling the air-flow metre with the ECU and the throttle body or combining the electronic controller of the ABS-system and the valve holder in one part.

5.2 The driving forces behind parts integration

Macro-economic changes were used as a point of departure (see Figure 5.3) in identifying four main driving forces behind the integration of parts described in the foregoing. These are illustrated below in order to better illustrate product integration and give the reader a better understanding of the research results presented and discussed in Chapters Six and Seven.

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[119] See Giga study, Automotive System Demand 1994-2003, May 1996, pp. 11-65; and, Duncan, C.I./Auzins, J., Electronics integration and architecture for cost savings and increased functionality, VDI-report, No. 1287, 1996, pp.734-739

[120] See Cambou, B.F., Microsystems for automotive application – semiconductor aspects, in: Microsystem Technologies, 1997, p. 105; and, Senninger, H./Bibby, R./Millen, On-engine capable engine control module: A comparison between today's and tomorrow's technology, VDI-report, No. 1287, 1996, pp. 529-533

[121] See Thoma, P., Future needs for automotive electronics, conference paper, Cambridge, USA, 10-12 Oct. 1994, pp. 532-539

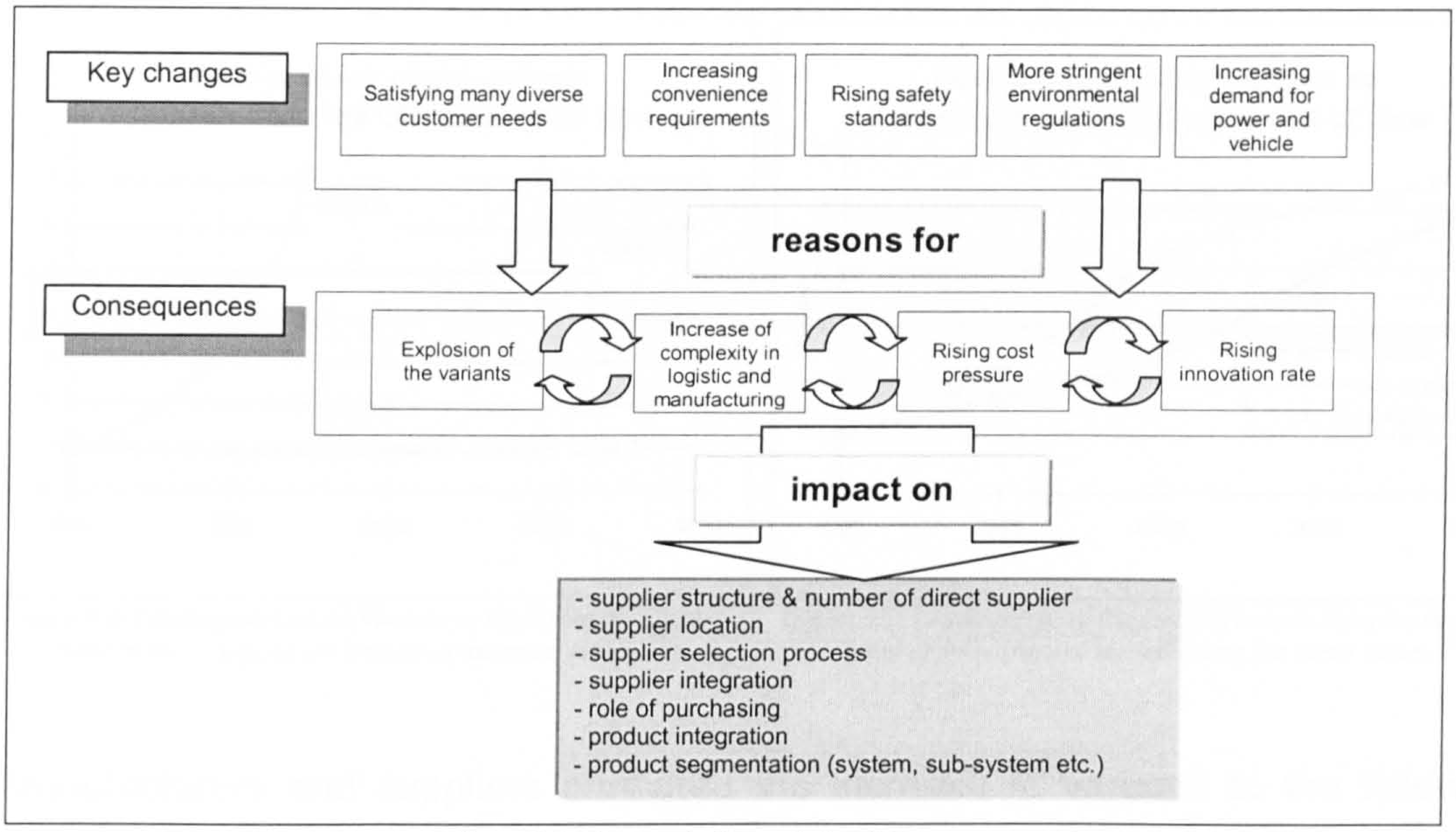

Figure 5.3: Changes in the market and their consequences

5.2.1 The explosive development of variants

The basis from which the diversity of variants originally developed changed drastically in the past decade. Nowadays, practically all carmakers sell the entire range of the most diverse types of vehicles (off-road vehicles, convertibles, roadsters, city cars, mini-vans, sports estates, small-sized and medium-sized vehicles and luxury vehicles). This trend has led to an explosion in the number of variants despite uniform parts concepts and platform strategies.

A study aimed at getting a better overview of this subject matter was performed within the scope of a graduate thesis written at the Fachhochschule Munich [122]. This study attempted to depict future developments in respect of variants and the complexity of products. Both parties - manufacturers and suppliers - were included in the survey in order to achieve a higher rate of redundancy.

The results showed a clear tendency, whereby the response from the companies who were invited to participate in the study was very weak (6 carmakers and 9 suppliers). Therefore, the results can provide no more than an approximate point of reference. In the study, the development of variants (Figures 5.4 and 5.6) was defined as the combination of options for equipment.

[122] See Herr, R., Lean Production - Komplexitäts- und Variantenentwicklung in der Automobilindustrie, diploma thesis, Munich, 1998

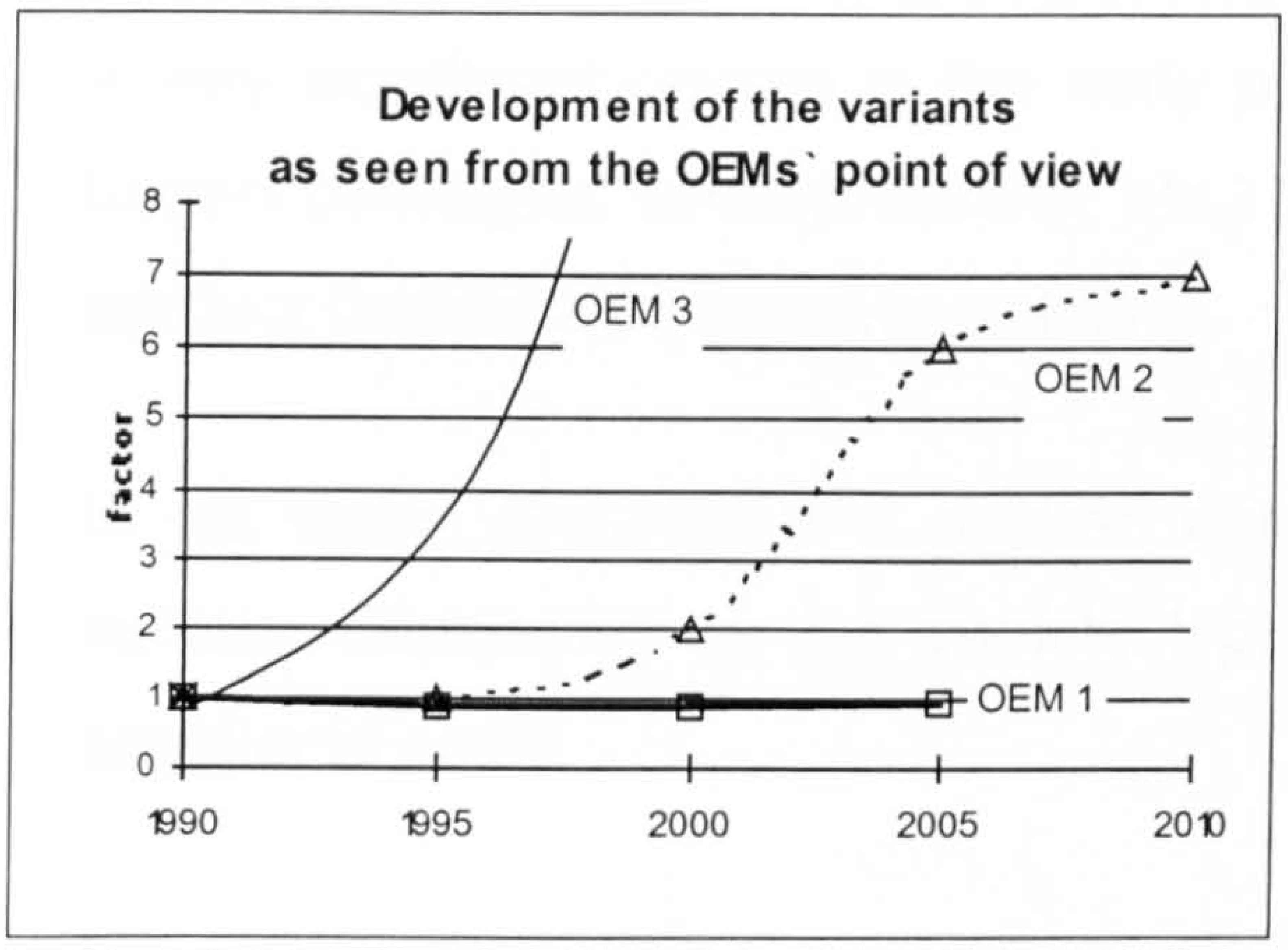

Figure 5.4: Development of the variants as seen from the OEMs` point of view (figures are indicating the mean values)[122]

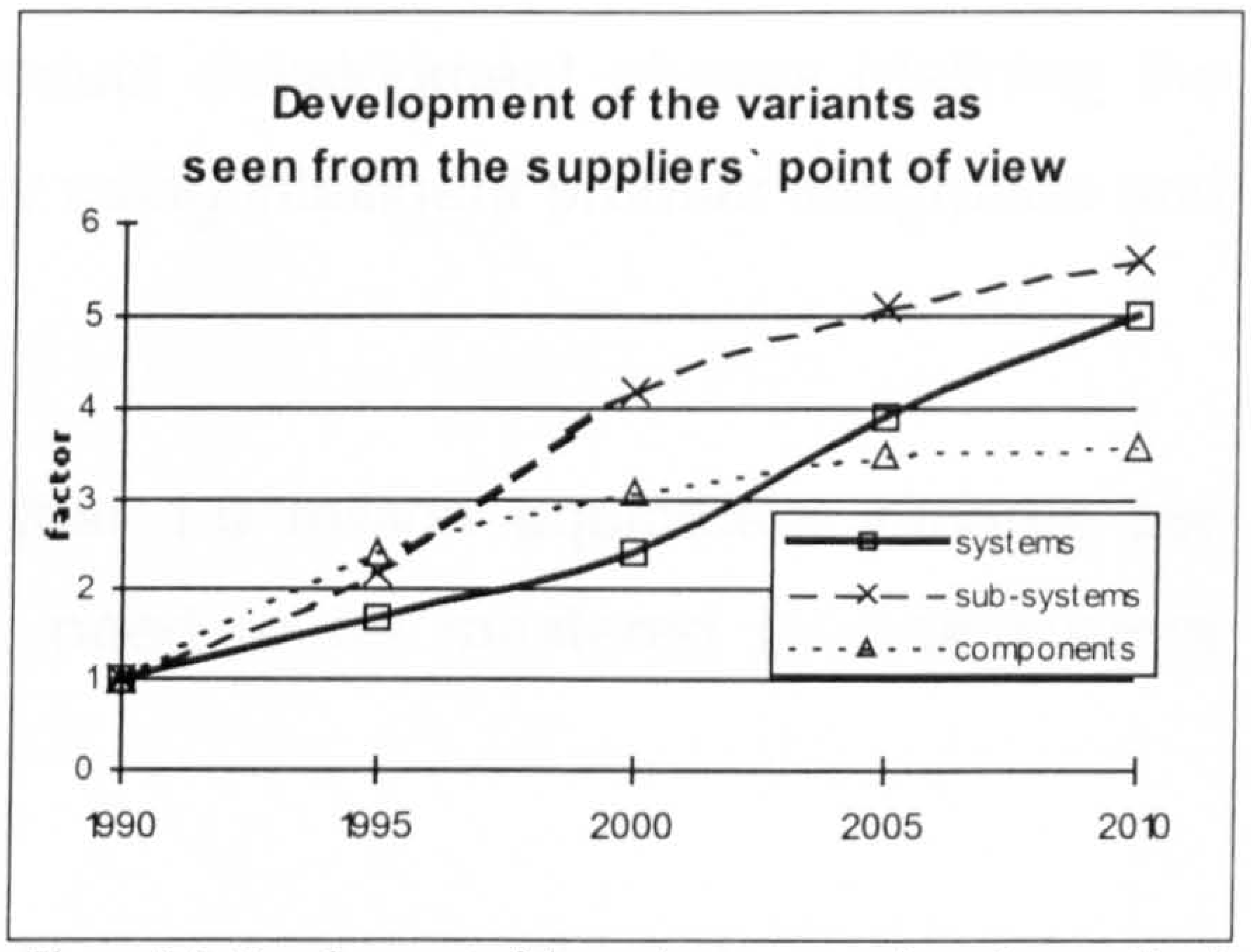

Figure 5.5: Development of the variants as seen from the suppliers' point of view (figures are indicating the mean values)[122]

Manufacturers and suppliers attributed the increase in variants to the following causes:

Reasons for the development of variants:	
From the OEM's point of view (listed in order of importance)	1) Customer requirements in respect of customisation 2) Pressure from competitive strength 3) Globalisation of the automobile business 4) Due to the development of new technologies 5) Innovative power of the supplier industry 6) Existence of specialised logistics systems
From the supplier's point of view (listed in order of importance)	1) Requirements/specifications of the OEMs 2) Globalisation of the automobile business 3) Pressure from competitive strength 4) Customer requirements in respect of customisation 5) The development of new technologies 6) The system supplier's specifications 7) Pressure from costs

Table 5.1: Reasons for the development of variants

The results relating to the increase in complexity are shown in the following (Figures 5.6 and 5.7). Here, complexity was defined with reference to the number of units per total vehicle as well per system, sub-system and component.

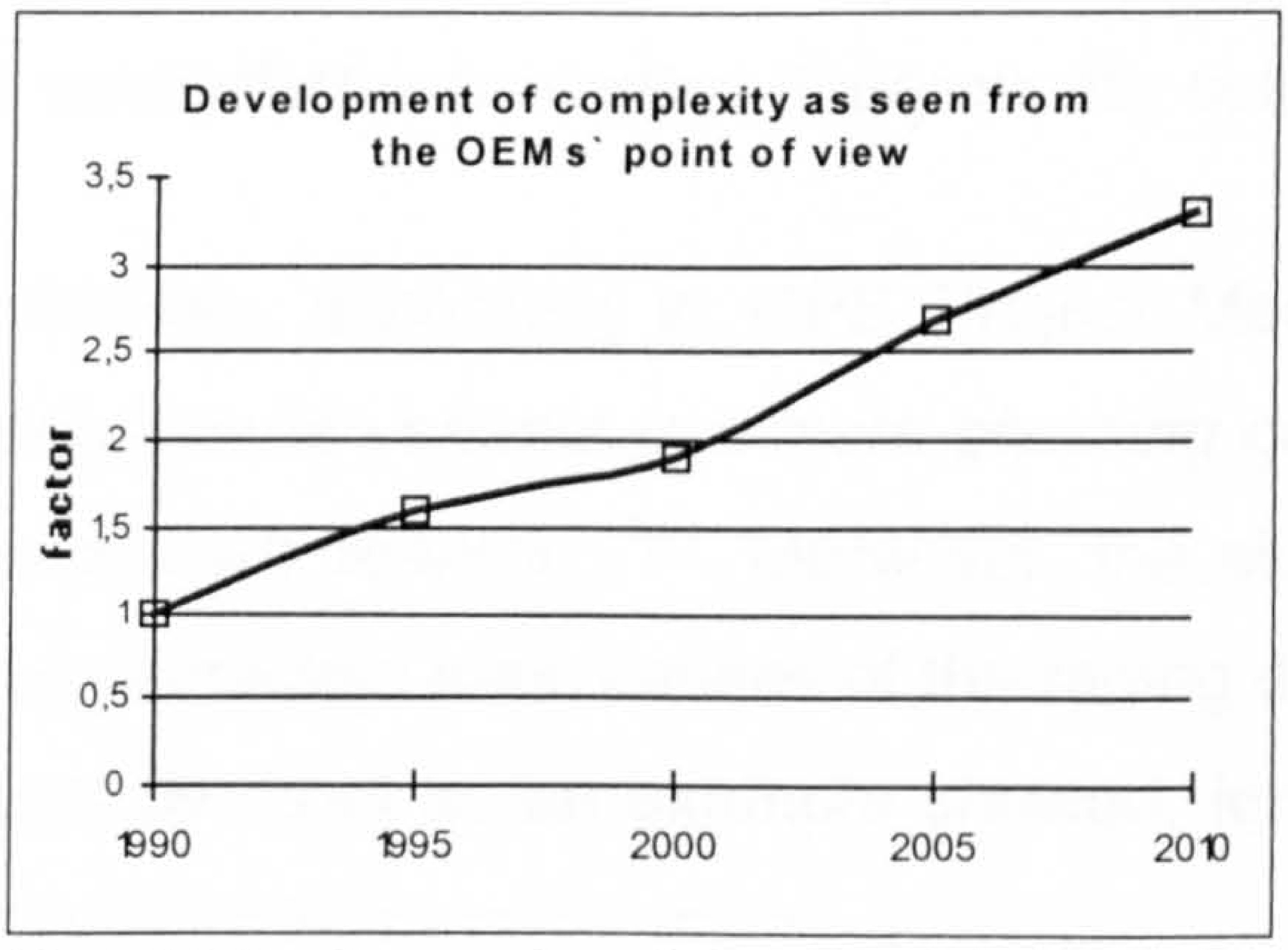

Figure 5.6: Development of complexity as seen from the OEMs` point of view (figures are indicating the mean values) [122]

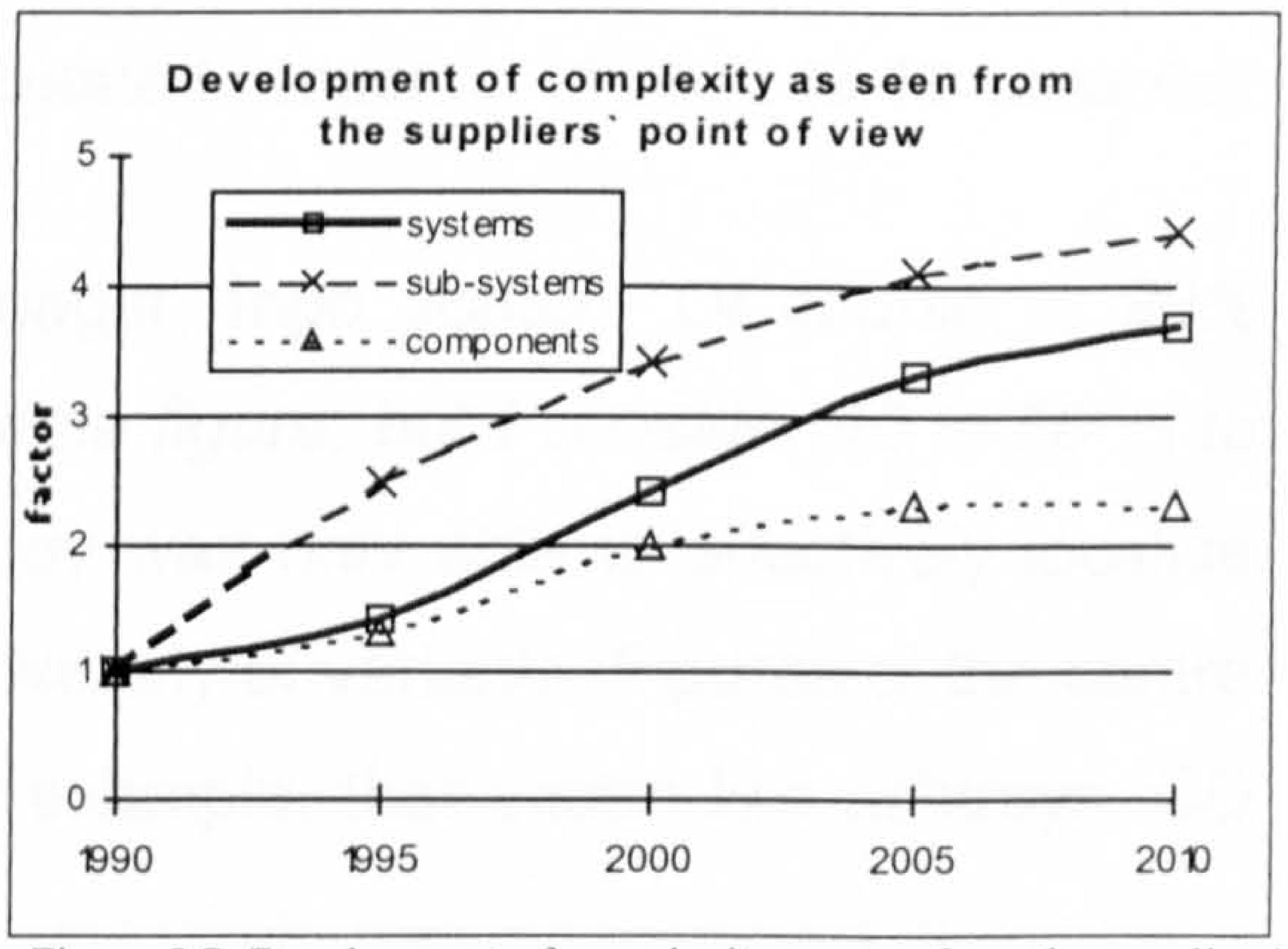

Figure 5.7: Development of complexity as seen from the suppliers' point of view (figures are indicating the mean values)[122]

This trend with its decisive effect on costs and quality can already be influenced to a very significant degree in the early product development phases (defining the targets catalogue, concept-finding, etc.) by using intelligent product integration and product combination (system building).

In his study, STANGER[123] pointed out that 1.0 million equipment variants per vehicle, depending on the vehicle type, need to be mastered by one system supplier of seats.

More modern software packages provide alternative options in addition to a reduction of the diversity of variants by applying the general approach of avoiding variants, or, as applicable, of radically decreasing the diversity of models in order to achieve an effective reduction in variants. The VMEA-Method (Variant Mode Effects Analysis) and the program that was specially developed for this purpose by GPS Software and Counsulting House can be used to analyse negative aspects of the diversity of variants for the individual company divisions by means of simulation calculations. This enables targeted measures to already be initiated prior to the start of the development phase[124].

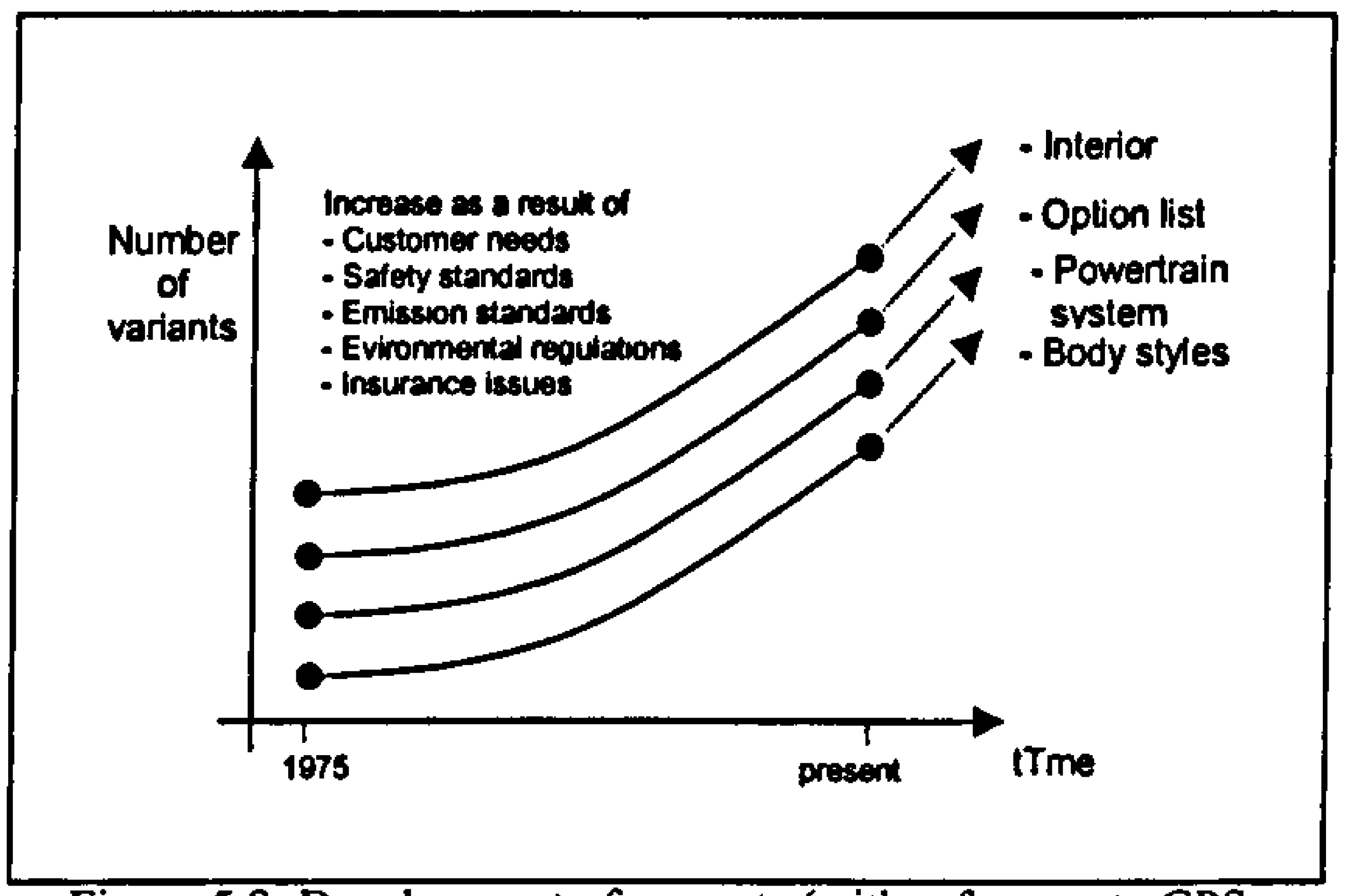

Figure 5.8: Development of variants (with reference to GPS, Automobil Produktion, Aug. 1997[124])

Nine projects aimed at investigating this topic were launched in 1995 within the scope of an integrated initiative of the Automobil NRW (VIA NRW). According to calculations, the aforementioned VMEA method and the so-called variants tree SW program were capable of achieving 13% potential reduction in variants in the joint shock absorber project and 98% in the centre console that was studied (theoretically calculated reduction of 3072 to 40 variants).

Whereas, according to GPS Project Manager, Ingo Jonas, "*Of course, a 99% reduction in variants is a mere planning game figure, but I consider 40 to 50 % to be entirely realistic* "[125]. Moreover, the study was only able to effectively localise the respective main causes of the raging diversity of variants. Figures of the centre console used as an example showed, for example, that extras like ashtrays, CD

[123] See Stanger, K., Projektmanagement entscheidet, Juli 1997, p. 78
[124] See Hassiepen, M./Schuh, G., Komplexität neu ausloten, in: Automobil Produktion, August 1997, pp. 216-217

boxes or cover plates with cigarette lighters raised the prices for the variants almost 32fold.

5.2.2 Increasing complexity – logistics, manufacturing, supplier interfaces

The literature contains a number of approaches specifically describing the complexity of the procurement situation. However, an extensive presentation of these would go beyond the scope of this paper. Therefore, the author would like to point out a few main approaches:

- FISHER[126] mentions product complexity and commercial uncertainty as determinants in describing a procurement situation. HILLIER[127] broadened this approach by adding complexity of human behaviour as a contributing factor.
- HAKANSEN, JOHANSON and WOOTZ[128] use the term 'uncertainty' more precisely. They distinguish as follows: Need uncertainty, market uncertainty and transaction uncertainty.
- HAKANSSON and OESTBERG[129] take the complexity of the product and customer-supplier interaction into account in their study.

Changes in the market (sociological and social trends, customers' individual demands and legal requirements, etc.) resulting in a dramatic increase in the diversity of parts and variants provoked a marked increased in the complexity of interaction processes (processes in connection with logistics and technical aspects relating to manufacturing) in the motor industry. One may conclude that the greater the need for diverse parts and components, the more complicated logistics and production become (Figure 5.9).

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125 Schuh, G., Kampf der Variantenvielfalt, in: Automobil Produktion, August 1997, pp. 220-221
126 See Fischer, L., Industrial Marketing, New York, 1970
127 See Hillier, T.J., Decision-making in the corporate industrial buying process, in: Industrial Marketing Management, 4/1975, pp. 99-106
128 See Hakansson, H./Johanson, J./ Wootz, B., Influence tactics in buyer-seller-process, in: Industrial Marketing Management, 5/1977, pp. 319-332
129 See Hakansson, H. /Oestberg, K., Industrial Marketing: An organisational Problem? In: Industrial Marketing Management, 4/1975, pp. 113-123

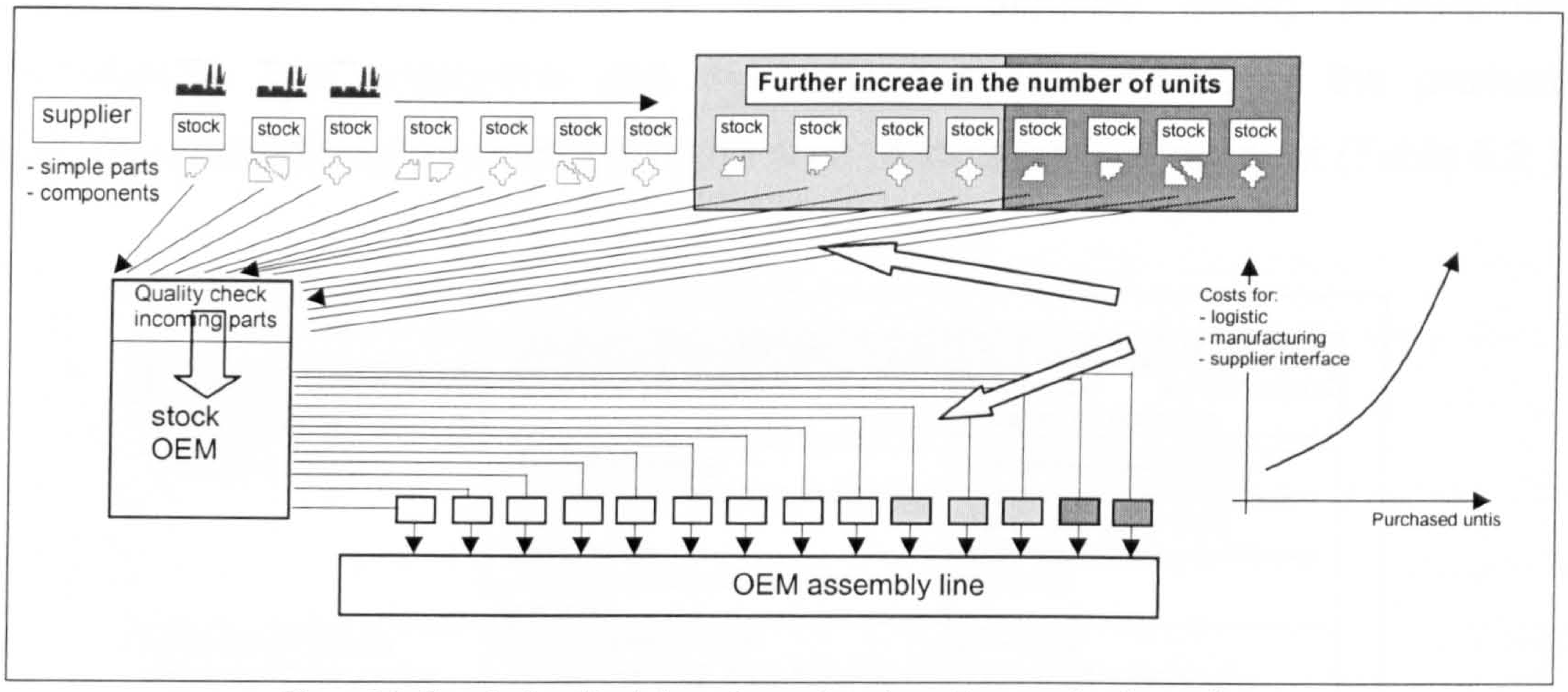

Figure 5.9: Complexity of logistics and manufacturing without product integration

The change in the procurement and car industry boundaries as already discussed in the introduction to this chapter triggered structural adjustments in the supplier chain and a shift in tasks and fields of responsibility. Carmakers need a high rate of flexibility in production and supply of materials (logistics) on the one hand and stable, long-term business relationships with fewer direct suppliers on the other hand to deal with market requirements successfully. At the same time, carmakers are faced with the conflict of having to lower costs by reducing their stocks without endangering the reliable supply for production and assembly while at the same time maintaining a high rate of flexibility toward the sales market.

In the past, manufacturers put their stakes on computer-integrated manufacturing, JIT production and JIT supply on the part of the suppliers in their efforts to solve this dilemma. Both of these concepts were aimed at achieving production that matched demand as precisely as possible with a low level of stock and short processing times for orders[130] in accordance with a “commercially optimum”[131] relationship directed to the outside. This can be achieved when all of the goods and services needed to perform an action are available in the necessary quantity, at the right time, at the right place and at a minimum of expense and is referred to as meeting the demands of external logistics[132], which cover the delivery period, readiness for delivery, delivery terms and reliability of delivery, etc.[133]. Various

[130] See Wildemann, H., Kundennahe Produktion und Zulieferung: Bestandsaufnahme in der Automobil- und Zulieferindustrie, 1989, pp. 12-20
[131] See Grochla, E., Grundlagen der Materialwirtschaft, 3. Auflage, Wiesbaden, 1978
[132] See Arnold, U., Logistik, in: Wirtschaftswissenschaftliches Studium, No. 3, March 1986, pp. 149-150
[133] See Pfohl, H.C., Zur Formulierung einer Lieferservicepolitik: Theoretische Aussage zum Angebot von Sekundärleistung als absatzpolitisches Instrument, in: ZfbF, 1977, pp. 239-255

strategies have been applied in the motor industry taking procurement synchronised with production and the various characteristics of the products requiring differentiated processing in the area of logistics into account (Table 5.2).

	Automobile manufacturer	
Supplier	Ordering via stock	Production synchronised order = JIT ordering
Supply from stock	**Double stocking:** - Reasonable for simple and low-cost parts - Very costly - Should be switched to single stocking	**Consumer-based supply:** - Supply based on consumption - No co-ordination of the manufacturing process between the parties
Order-synchronised supply = JIT production	**Stock-based supply:** Supply based on stock development at the OEM's. More intensive exchange of information and communication. More efficient production planning at the supplier's	**JIT supply:** - High synchronisation of volume, time and quality among the parties

Table 5.2: Different logistic concepts (source: Sauer K., 1990, pp. 233 ff.)

The development of new methods and processes in addition to communication means and options provided carmakers with instruments enabling them to at least master this situation. Due to the fact, though, that these had also reached their limits, the companies were forced to initiate conceptual changes in product segmentation[134]. This manner of proceeding and the accompanying reduction in the number of supplier interfaces (Figure 5.10) coupled with an improvement in the exchange of information and communication between the OEMs and the suppliers made it possible to shorten the time required for assembly on the one hand and to improve reliability and quality, while at the same time reducing the complexity of delivery and production on the other hand. This has resulted in savings in respect of resources and storage and consequently in cost savings.

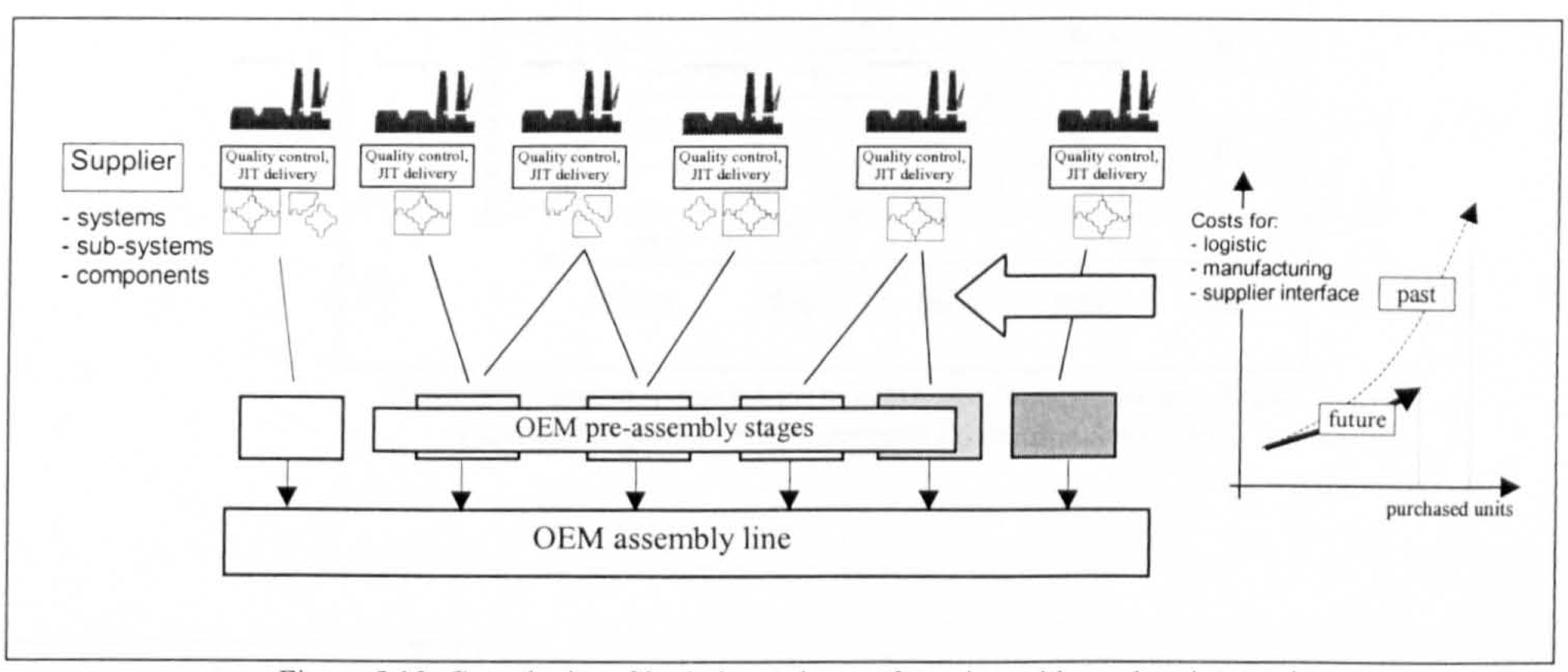

Figure 5.10: Complexity of logistics and manufacturing with product integration
-system building-

[134] See w.A., Solotänzer haben keine Chance, in: Automobil Produktion, Nov. 1988, pp. 26-32

5.2.3 Pressure from costs

By contrast with the 1970s and also the 1980s to a certain degree, where a brand's image, quality and functionality influenced the buyer's decision to purchase a certain vehicle, the factor of costs along with quality and performance in terms of innovation and service are among the main criteria affecting competition in the international motor industry of today[135]. In connection with this topic, DaimlerChrysler (Stuttgart) draws attention to the stiffening of international competition with reference to the four dimensions of costs, quality, time and engineering[136]. Japanese manufacturers have set new standards in this field, thereby putting enormous pressure on European and American carmakers. As demonstrated by the comparisons in the MIT study, they have been able to exhibit advantages in numerous areas (see point 4.2).

Whereas the Japanese took 1.7 million design hours to develop a 14,000-Dollar car with two car body forms in the compact-car class, competitors from the West took almost double that. Similar advantages were also shown in productivity (productivity in production and in development) and quality[137]. Beyond this, Japanese manufacturers offered a significantly higher rate of equipment per vehicle, a fact that was viewed very favourably by customers. These constituted factors that seriously aggravated the situation in the West in terms of costs and competition as clearly reflected by the shifts in market share (Figure 5.11).

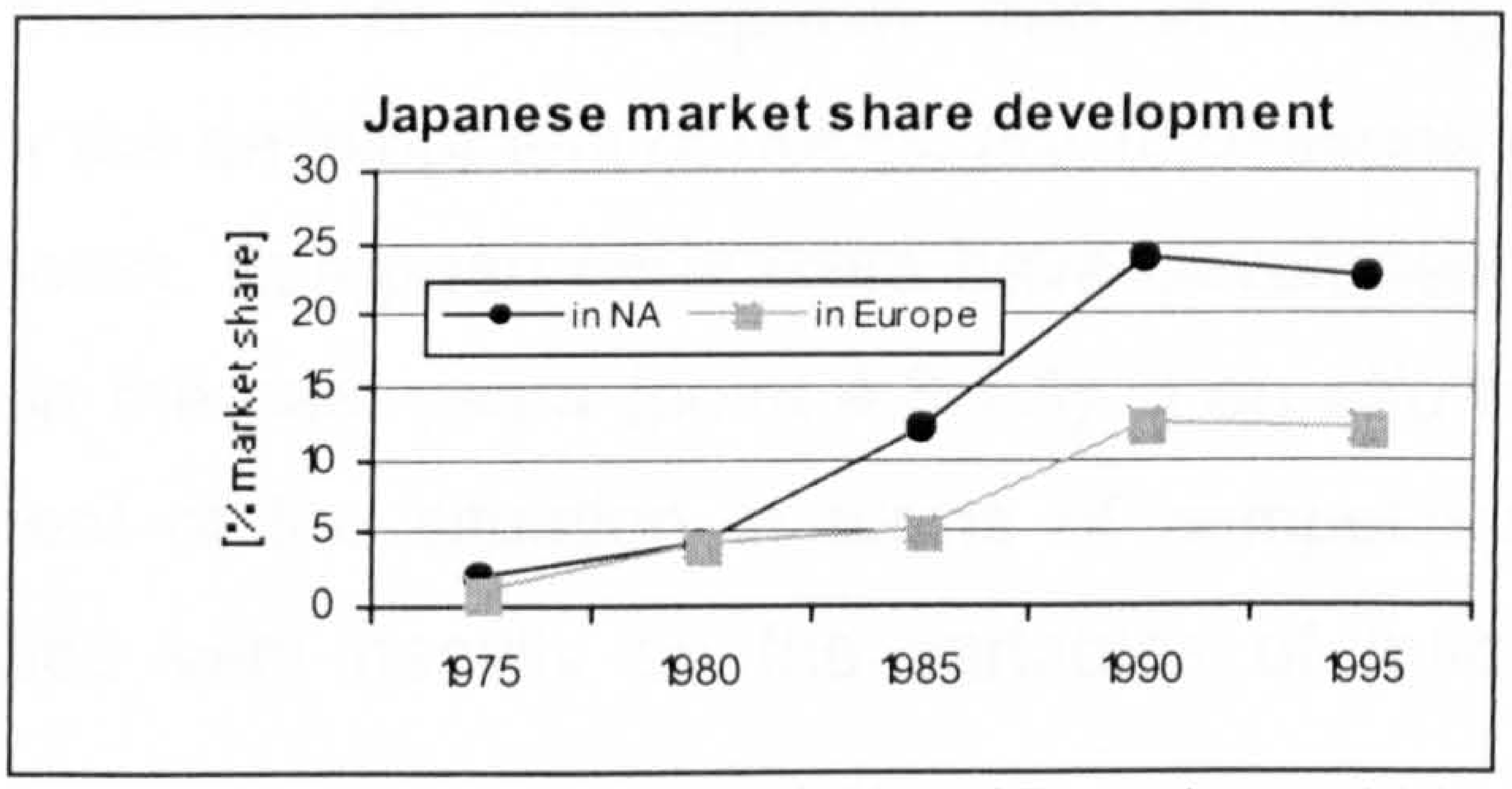

Figure 5.11: Japanese market share in NA and Europe (source: AAA, Facts and Figures, 1997; Automobil Produktion, Nov. 96)

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[135] See Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, 1993, p. 118; Interview with Mr. Rudnitzki, Die Kostenlücke dramatisch verkleinert, in Automobil Produktion, August 1995, p. 29; Hofmaier, R., Wertschöpfung aus Winner-Position, in, Absatzwirtschaft, 4/1993, p. 62; Müller, U., Integration of development partners in the car development process, conference paper, 1994, pp. 1-10

[136] See Remmel, M., Ein Blick über Tandem hinaus, conference paper, Automobil-Forum, Stuttgart, 1996

[137] See Clark, K.B./Fujimoto, T., Automobilentwicklung mit System, Frankfurt/Main, New York, 1991

COOPER points out the relationships of the important orienting factors of price, functionality and quality with reference to the diverse strategic alternatives of technology leader (innovator), cost leader and differentiator (Figure 5.12). He refers to this relationship as the "survival triplet" and goes on to explain the "survival zones" for mass producers and lean producers[138].

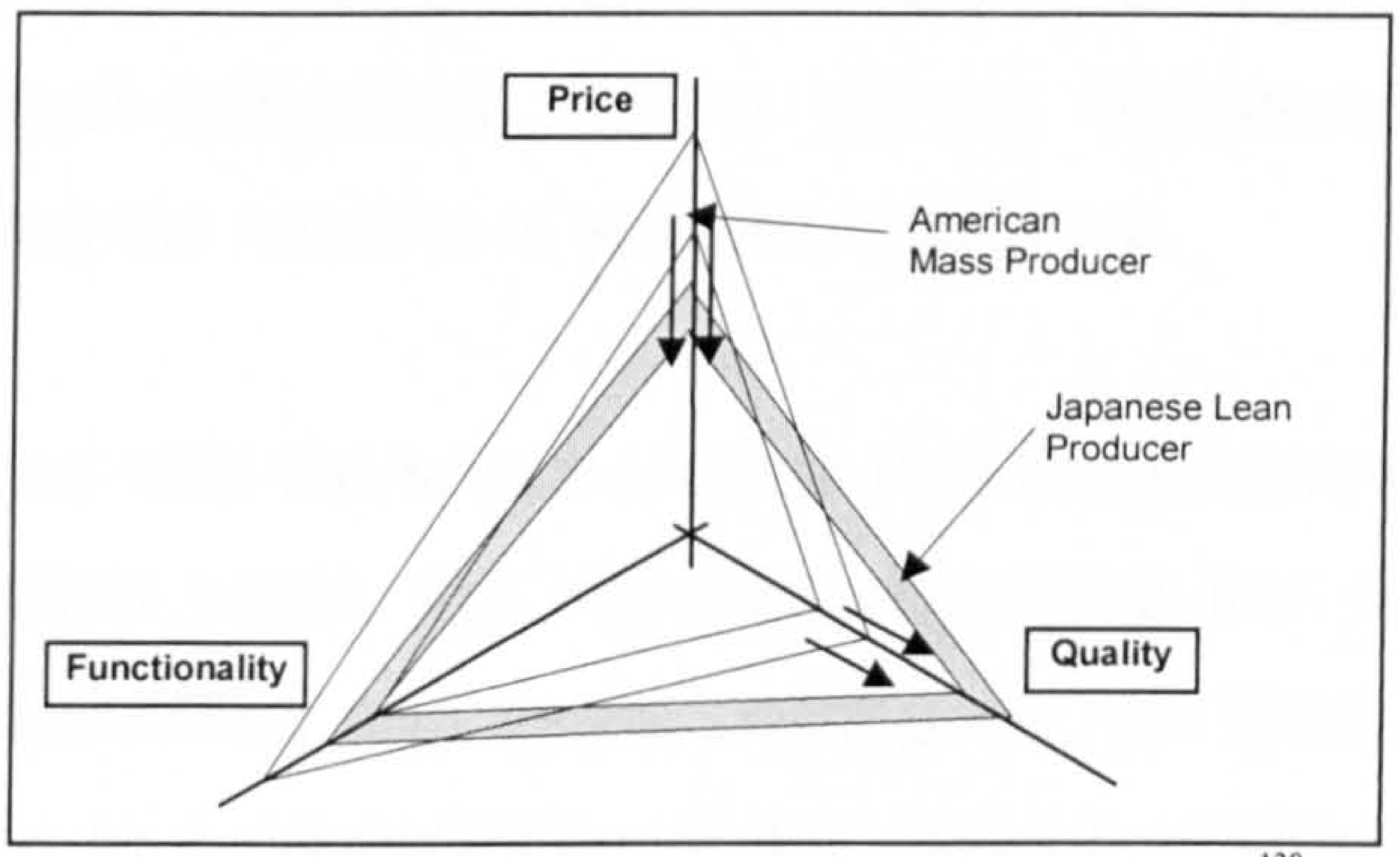

Figure 5.12: Survival zone - mass producer, lean producer - [138]

Contrary to other branches of industry[139], all three factors need to be treated as equally important and are significant in the motor industry due to the prevailing competition conditions. Granted, evading competition by focusing on one of the variables mentioned in the foregoing might result in short-term success, but it cannot offer any chances of survival in the long-term. Accordingly, any confrontation with other competitors must by force take place in all three areas, whereby it would take on different forms. Pressure will also continue to increase with reference to the costs mentioned in this section. This is due to the constantly increasing intensity of competition provoked by stagnating growth in automobile production in the presence of over-capacity and increasing dependency on resources needed for the development of necessary innovations (product solutions and marketing solutions). European carmakers have developed and introduced a variety of programs in the past years (point 4.3.1.3) in an effort to finally achieve long-term improvement of the situation in terms of competition and yield after originally having relied very heavily on the variables of automation and staff reduction.

By implementing the tandem program in many joint projects, for example, Daimler-Benz (now DaimlerChrysler) was able to reduce costs by up to 40%, resulting in

[138] See Cooper, R., When lean enterprise collide: Competing through confrontation, in: Harvard Business Scholl Press, Boston, 1995, pp. 27 ff.

[139] E.g. Nike consistently followed the strategy of technology leader and the market accepted the higher prices of Nike's products; K-mart concentrated themselves on cost leadership and the market accepted the lower quality they supplied

overall savings to the amount of 1 billion Deutschmarks in 1993 alone. VW expected to achieve at least 30% reduction in costs by using measures like restructuring and placing orders for 100 percent of the supply volume for a model's entire life span[140].

Companies hope to effect further necessary improvements by reinforcing the continuation of product integration (which will be discussed in detail in the following) and reducing the number of supplier interfaces.

This paper will not deal with the specific topics that are relevant for costs such as process and transaction costs, the situation regarding the cost of labour and related costs, cost controlling and target costing etc, as firstly, they are only of secondary importance in a presentation of the working environment and working goals and secondly, because they would exceed the scope of the paper and interfere with its aim of processing the relevant information in a suitable and professional manner. Therefore, only a few of the diverse items available in the literature on the subject[141] have been mentioned.

5.2.4 Innovation

Naturally, the strong pressure from costs has forced companies to save in all areas, although the budgets for research and development were usually those to be cut first due to their relatively easy accessibility. It may be interesting to note here that, prior to publication of the results from the IMV Program, in many cases, the European motor industry had only reacted to demands from the outside (particularly in the form of laws and regulations). It was not until later that companies began demonstrating greater readiness to innovate. LAMMING refers to the supplier industry using the concept of proactive action in order to be in a position to assume a role as a key-player[142].

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[140] See Remmel, M./Rudnitzki, J. (Interview), Kosten um 40 Prozent gesenkt, in: Automobil Produktion, April 1994, p. 112; and, Wilde, W., Der Vollstrecker, in: Manager Magazin, 1/1993, p. 36

[141] Regarding process costs see, Holst, J., Lean Development, 1995; Eversheim, W., (editor), Prozeßorientierte Unternehmensorganisation, 1996
transaction costs see, de Pay, D., Die Organisation von Innovationen, PhD thesis, 1988; Henkel, C., Akqusitionen and Kooperationen als strategische Alternative aus Sicht der deutschen Automobilindustrie, PhD thesis, 1992
target costing see, Cooper, R., When lean enterprise collide, 1994, pp. 134 ff.
labour-/indirect labour cost see, Internationalisierung – Chancen and Risiken für die Zulieferindustrie, Bericht 46, Wuppertaler Kreis, pp. 40 ff.; cost-controlling see, Saad, K.N./Roussel, P.A./Tiby, T., Management der F+E-Strategie, 1993, pp. 82-86

[142] See Lamming, R., Die Zukunft der Zulieferindustrie, 1992, p. 296; Clark, K.B., What strategy can do for technology, in: Harvard Business Review, Nov/Dec. 1989, pp. 94-97, Clark describes the five rules of technology leadership in his article

Whereas, in this context, the innovative feats in process engineering, materials engineering and processing technology along with the waves of innovation they elicited formed the triggering factors leading to the explosive development of variants and increase in complexity mentioned in the foregoing, they have also provided, and will continue to provide, the necessary means for elaborating solutions to existing problems.

The triggering factors leading to the waves of innovation[143] shown in Figure 5.13 and the systems resulting from them (Figure 5.14) have varying origins. It is precisely this fact that makes this branch of industry so unpredictable and interesting at the same time.

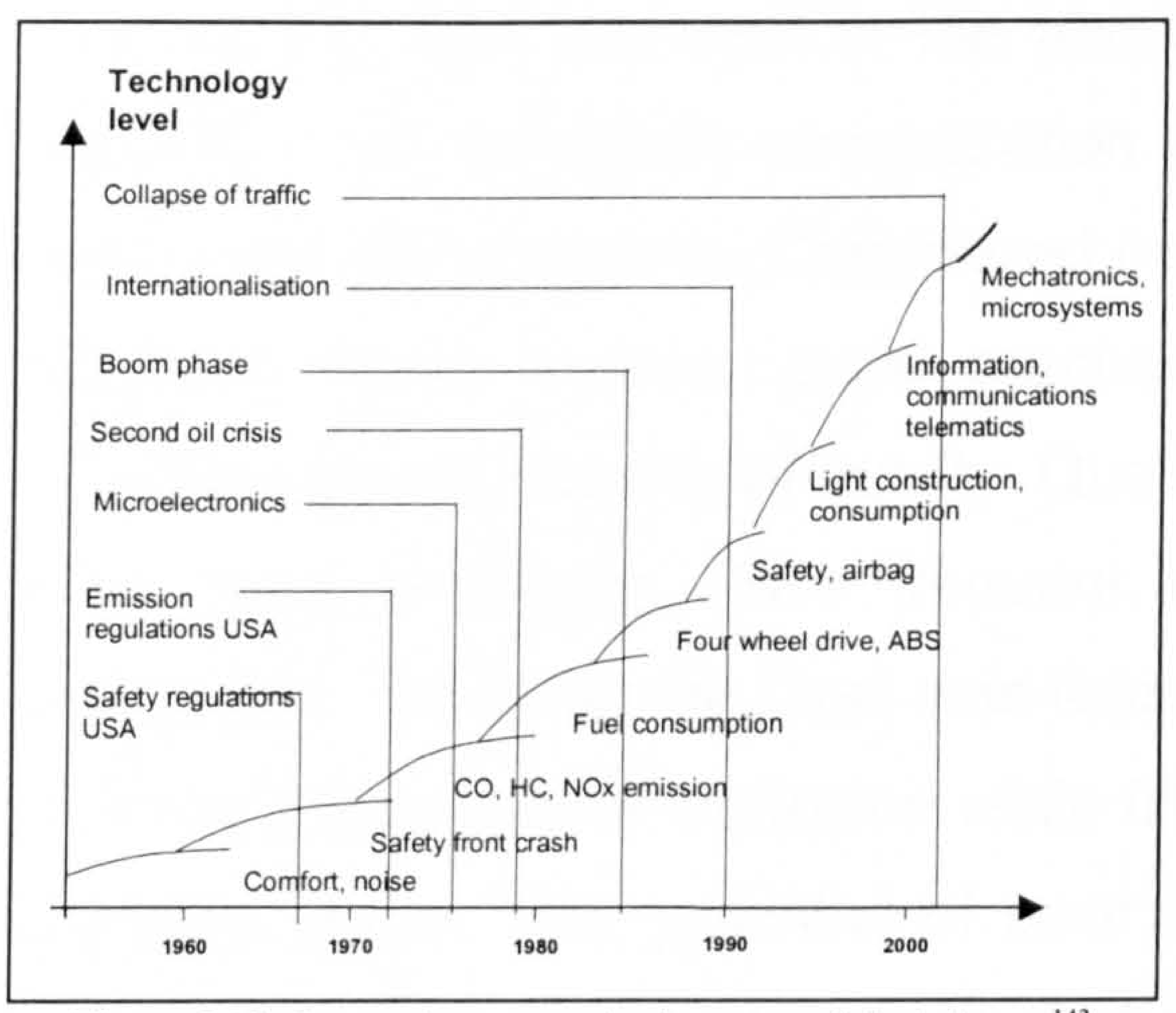

Figure 5.13: Innovation waves in the automobile industry[143]

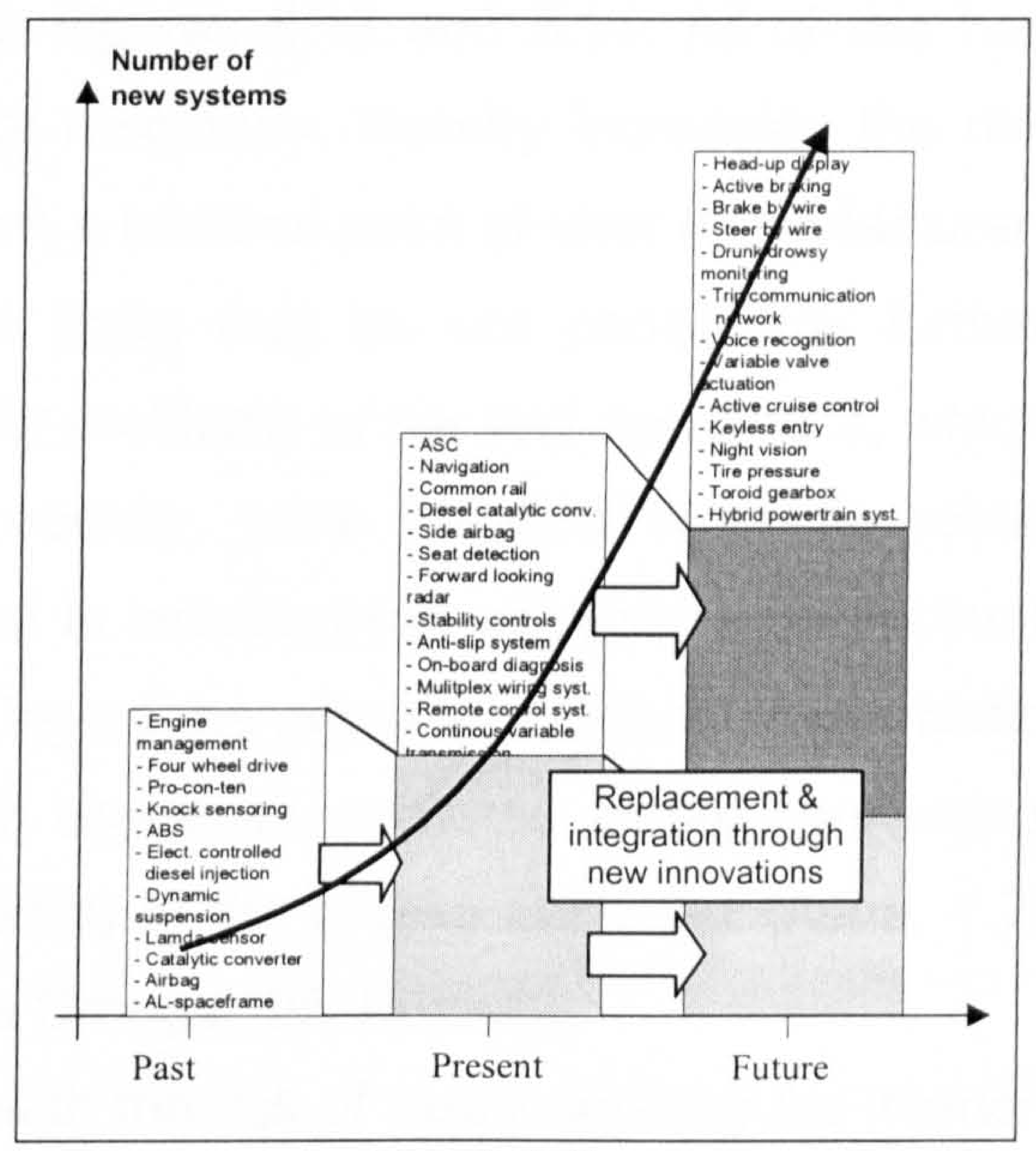

Figure 5.14: New systems

In addition to customers' needs, environmental requirements and safety requirements that have to be complied with, a major share of the systems introduced can be traced back to the enormous progress made in the semiconductor industry. Miniaturising (integration) along with simultaneous enhancement of the performance data and power (computing speed, memory capacity) have made it possible to access fields that would have been unthinkable in the past[144]. Accordingly, experts estimate that the share of semiconductor

[143] See Seifert, U., Automobiltechnik zur Jahrtausendwende, in: Meinig, W. (editor), Auto-Motive 97

[144] See Cambou, B.F., Microsystems for automotive application - semiconductor aspects, 1997, p. 103; Ruge, I., Chancen and Risiken der Miniaturisierung elektronischer Bauelemente, conference paper, Stuttgart, 1995, chapter 7 of the conference handout

technology per vehicle will climb from DM 93 in 1992 to DM 375 in the year 2000[145]. Mr. Schulz, Member of the Temic Managing Board, goes so far as to venture that the share of electronic parts in an upmarket vehicle, currently at DM 3150 will practically double in the next five years[146]. Beyond that, market analysts estimate that the share of electronic components will climb to 25% of the entire value of a vehicle in the year 2000. These figures already show clearly that the fields of responsibility will inevitably end up shifting to the effect that more and more electronic know-how carriers will assume the leading role in a field where mechanics once dominated. This consideration is of special interest to electronics suppliers, particularly in view of the mechatronic tendencies[147]. The investigations conducted in this study were aimed at assessing this trend more precisely.

Ever shorter periods available for the development of increasingly complex systems are also apparent in the above Figures 5.13 and 5.14. All of this has resulted in an inevitable concentration of resources, thereby increasing the risk companies must assume. Considered from a bilateral point of view (manufacturer-supplier), those involved have reached limits that do not permit any further reduction due to reasons of quality. Quality problems at the end customer's, which have been becoming more frequent recently, have resulted in costly recall campaigns. For example, Opel was forced to launch recall campaigns on account of: Potential danger of explosion while filling up the petrol tank due to electrostatic charging (Astra, '94), potential of error in connection with the airbag connecting plug (Astra, '94), potential danger of shorting in the engine cable set (Astra, 1.7l Diesel, '95), insufficiently fixed petrol hose Omega, '95, Europe);
VW due to: Errors in the heating system with the risk of water entering the interior (Golf, Jetta, '95); improvements had to be made to the wiring of the manual gearbox and the computer system ('95, Japan); potential trouble with electric cables in the engine compartment (Beetle, '98, NA);
Porsche on account of: Replacement of the ignition starter switch housing (Boxter, '98);
Mazda due to: Brittle valve springs (Mazda 323);

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[145] See Martin, B., Zweitgrößtes Marktsegment bis 2005, in: Automobil Produktion, Dec. 1996, pp. 108-112
[146] See hereby, Der Dollar rollt, in: Automobil Produktion, April 1998, p. 62; and, w.A., Am Lenkrad Internet surfen, in: Automobil Entwicklung, Sept. 1997, p. 46
[147] See Ehlers, K., Automobilelektrik – Start gelungen, wie geht es weiter?, 1986, p. 568, Ehlers indicates in his article the performance increase through the combination of mechanic+electronic

Daimler Benz (now DaimlerChrysler) due to: Potential trouble with the brake assistant ('97), driving stability (A-Class); the Smart's market launch was delayed for this reason;
Audi due to: Potential of errors in the airbag signal line ('97);
Ford due to: Mounting of a heat shield on the EGR-valve (exhaust gas recirculation valve), parts of the engine damping that had fallen off or been torn off accompanied by a risk of igniting (Galaxy 2.0 and 2.3l, '98)[148].

Granted, we cannot attribute these consequences directly to the stringent restrictions in terms of time and money available for development, which in turn affect the available options for testing. However, they do indicate the fact that companies are working under marginal conditions.

An ABB manager once referred to these problems and with reference to the power plant business in particular using following wording: "*We are banana merchants who sell products that ripen at our customers'*[149]. Carmakers are doing their best to minimise risks by having jobs, that are not among their core competencies or that they do not consider important in distinguishing their own products, provided by outside sources. This is particularly important in view of future product integration and the essential need for specific product and production know-how.

5.3 The system approach

Carmakers are increasingly putting their stakes on product integration - system building - in order to put themselves in a position to better handle the problems addressed in the foregoing. Procurement is generally aimed at ordering entire systems from the supplier in respect of development engineering and production engineering. These trends result in changes inside the company and outside in respect of the development process, production structures, extent of know-how, information management and interdisciplinary joint work and will continue to do so to an even greater extent in the future, whereby they primarily affect the level of corporate vision and corporate strategy. All of this results in long-term orientation, particularly as regards the supplier industry, gaining special importance. If we draw a parallel to the developments in the semiconductor industry, for example, which

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148 See Autmobil Produktion, Dec. 1996; ADAC-Motorwelt, Mai 1996; Amberger Zeitung (local press), edition 30.8.95 and 15.6.96
149 See w.A., Schwache Leistung, in: Manager Magazin, April 1998, p. 40

can only be valid to a certain degree, of course, we find incredible potential in the motor industry as regards reduction of costs on the one hand and enhanced performance on the other hand. The number of direct suppliers will decrease drastically as a result of the shifting and concentrating of value creation that will take place in the course of the implementation of the system approach.

The fact that the value creation furnished by all of the suppliers up until now cannot be furnished by a small number of system suppliers will lead to the creation of a supplier structure (pyramid) that will furnish the same value creation as all of the suppliers taken together in the past. In this situation, the component suppliers will be subject to keen national and international competition due to the fact that manufacturers will be especially motivated to apply global sourcing in order to take advantage of cost benefits when it comes to ordering standardised components or components subject to legal requirements, as applicable.

This becomes all the more valid in view of the fact that the lead in quality that European manufacturers used to have compared to the Third World countries is decreasing more and more[150].

Current examples and the associated opportunities and risks for the individual levels of the value creation chain will be presented subsequently in order to provide a point of departure and instruments for comparison for analysing tendencies of standardisation in system building among the OEMs studied.

5.3.1 Examples of the system approach

The manner in which the overall product is segmented into individual systems that are developed and delivered by a reduced number of so-called direct suppliers who are in charge is primarily in the foreground when system building is being discussed. The various definitions and uses of terms (systems/modules, etc.) used by the individual carmakers are of secondary importance in these discussions. However, it is important to be aware of what the extents of the systems with reference to direct contacts, development partners and supply partners will look like in the future. A few examples that can be found in the literature will be

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[150] See Bullinger, H-J./Thaler, K., Vom Teilefertiger zum Wertschöpfungspartner, 1993, pp. 24-27; and , Wildemann, H., Optimierung von Entwicklungszeiten, 1993 , p. 396

presented subsequently for this purpose. They are intended to provide an initial overview on the one hand and to verify the results of the empirical investigation presented in Chapter Six, which reflects the extensive and detailed character of this subject matter, on the other hand.

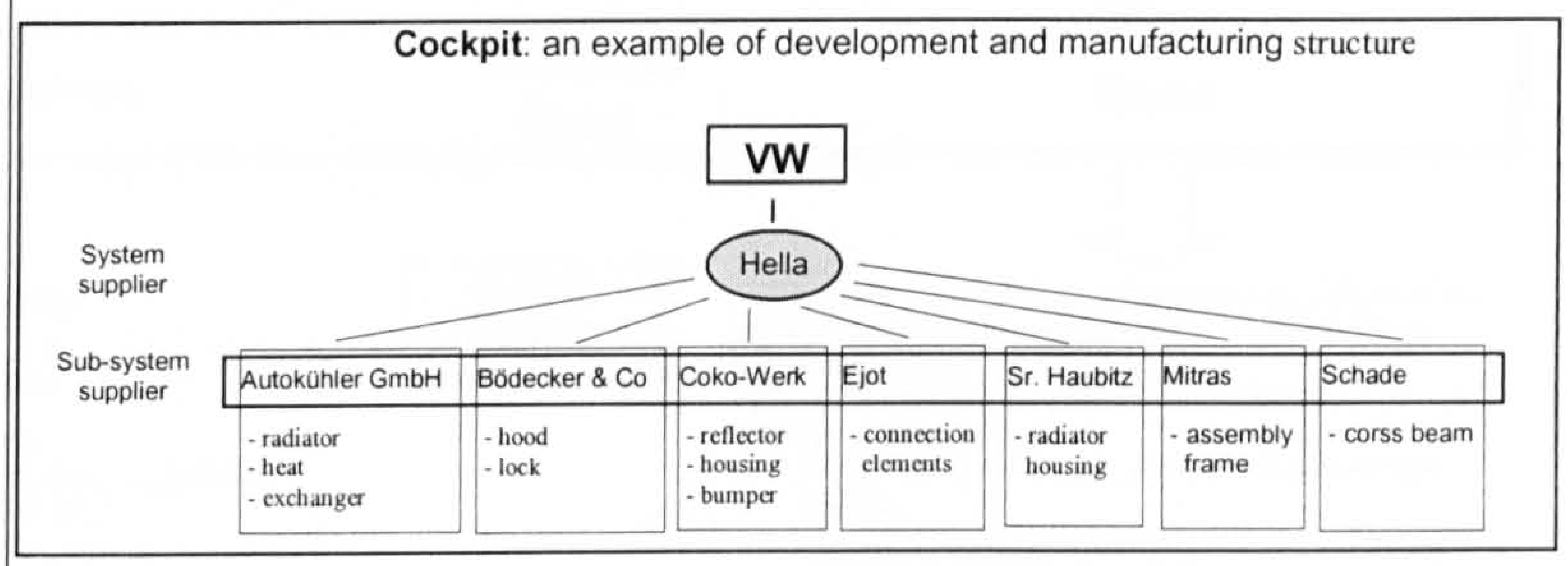
Example:	
Audi, A3[151] (development and assembly modules)	Cockpit, front end, bumper, suspension, wiring, door module, seat, exhaust system, tank, body, sun-roof
BMW[152] (structure of modules)	Cockpit, instrumentation, wiring, communications system, central electrical system, doors, body, seats, fuel system (fuel supply), interior top/bottom, boot hood/front hood, braking system, front/rear suspension, steering wheel/pedals, exhaust system, gearbox (rear engine and drive train), heating/air conditioning, engine system/cooling system, front end, circulation system
VW, Golf IV[153] (the creation of product modules improves the variants situation)	Cockpit, front end, engine, doors, seats, tiers, boot lid, front bonnet[154] 
MCC (Smart)	Body, cockpit, electrical system, door panels, exhaust system , engine/gearbox
Opel[155] (modular vehicle concept)	Cockpit, seats, restraint system, exhaust system, doors, suspension components, heating/air conditioning, bumper, engine cooling, fuel system, headlining

Table 5.3: Examples of systems/modules

5.3.2 Opportunities and risks for the supplier industry

System building and the placing of greater volumes of procurement orders to fewer direct suppliers taking over development, production and delivery will continue to increase the effectivity in the various areas - development, logistics, production, etc. - and to reduce costs further.

These changes and the accompanying dramatic shifts in the supplier structure entail opportunities in respect of growth and increases in turnover to the same

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[151] See Hackenberg, U., Methodik vernetzter Fahrzeug-Entwicklung am Beispiel Audi A3, conference paper: Entwicklungsperspektiven für Automobilhersteller and Zulieferer, Stuttgart, 1996

[152] See Thoma, P./Preissler, H.J., Fahrzeugelektrik - gemeinsam zum Spitzenprodukt, conferenz paper: Fortschritte in der Automobilelektronik, Stuttgart, 1995

[153] Winterkorn, M. (Interview), Beschaffungsprozeß, in: Automobil Produktion, special edition VW Golf, Oct. 1997, p. 28

[154] w.A., Front-orientierter Auftritt, in: Automobil Industrie, 2/1996, p. 31; Schernikau, J., R&D – Management for Moduls and Systems, project study, RWTH Aachen, 1997

[155] See Demant, H.H., Kooperative Entwicklung im Zeichen kurzer Entwicklungs – Kriterien einer fairen and effektiven Zusammenarbeit mit den Zulieferern, Stuttgart, 1994, p. 23

degree that they harbour risks for the suppliers that are particularly relevant for their strategic orientation and definitions of targets (Table 5.4).

Carmaker

Opportunities

- Reduction in the number of suppliers; system supplier is the contact partner; it co-ordinates development activities within the supply chain
- Cost saving through pre-assembly at the supplier's
- Cost saving by having the system supplier do the quality check
- Combining functions, saving weight and costs
- Reduction of logistic efforts
- More efficient product development and component adjustment through earlier supplier integration

Risks

- Loss of know-how to the system supplier
- Hampered intention of price reduction
- Product substitution and supplier change is difficult
- Sometimes, the stringent requirements can not be met by the system supplier, leading to frustration on both sides
- System building requires internal restructuring
- Re-structuring the assembly line may create difficulties

Creates Risks and Opportunities for the different supplier levels

Supplier level

System Supplier

Opportunities

- Strengthening the market position
- Increasing sales volume
- Improving information and know-how flow through better integration
- Getting first-hand information
- Better basis for future planings through product-life contracts and early commitments

Risks

- Alliances/acquisitions are often necessary in order to close know-how gaps, which lead to investments, re-organisation, re-structuring etc.
- Pre-financing R&D, logistics quality control, manufacturing efforts
  - R&D: The supplier presents solutions; the OEM selects
  - Logistics: For warehose/buffering and JIT delivery
  - Quality control: The supplier is responsible for the whole system
- OEMs are shifting cost intensive activities to the system supplier
- International presence is required
- Very tense international competitive situation
- Dependency on few OEMs
- Loss of flexibility
- Lack of control over information disclosure (cost/development transparency)

Sub-System Supplier

Opportunities

- Increasing profit situation through less required investments comparing to those of the system supplier
- Potential to develop to a system supplier
- Relationship to the OEM is not as tight as those of the system supplier what creats more flexibility

Risks

- Second-hand information
- Losing contact to the policy-maker (OEMs)
- Poor basis for planing due to second-level position; life-time contracts are seldom
- System supplier will move undesired and cost-intensive tasks to sub-system supplier
- High cost pressure from the system supplier
- International presence very often required

Component Supplier[156]

Opportunities

- Good market position for cost leader
- Chance for product standardisation is good
- Flexibility is higher than those of the system supplier

Risks

- Product substitution is very high
- Differentiation possibilities very limited
- High number of competitors
- Future planing is difficult, third-level position, no life-time contracts
- Prices are renegotiated each year

Table 5.4: Opportunities and risks for OEMs and suppliers due to stronger integration and changing of the supplier structure

[156] See Oakes, I.K./Lee, G.L., Approaches to innovation amongst component suppliers: some smaller firm perspectives, in: IJTM Special Issues on Resources for SME Innovation, Vol. 12, No. 7/8, 1996, pp. 808-817, The authors relate approaches to innovation amongst smaller firms to changes confronting component suppliers

5.4 Summary

The influencing factors and effects were described in more detail in this section as a basis for the discussion of the system-building scenario and standardisation tendencies that will follow in a later section.

The number of variants of required production units needing to be co-ordinated has reached its limits due to increasing demands in respect of customer needs, safety requirements and environmental standards that need to be satisfied as already mentioned several times in the foregoing. This situation makes it necessary to pursue new paths in product development and production control so as to master the complexity in logistics and vehicle assembly and improve efficiency.

Increasing pressure from costs and innovation cycles that are becoming ever shorter constitute additional factors that make product integration imperative and that have allowed parts and components that were once out-sourced individually to be merged into a unit. This describes a path for both parties, the manufacturers and the suppliers, that can entail opportunities as well as risks.

A few accessible examples already show (see Section 5.3) what this form of product (vehicle) segmentation might look like. It may be noted that this cannot yet serve as a basis for identifying tendencies of standardisation and that the inconsistent use of the classification of terms does not permit any clear-cut comparison.

A more precise analysis of this system-building scenario (standardisation trend) constitutes the aim of this investigation.

Chapter Six: Investigation of the system-building scenario

6.1 System building standardisation trends among the OEMs

6.1.1 Research plan, interpretation and visual representation of data

Chapters Six and Seven present the results of a primary analysis carried out at European carmakers from January 1997 through March 1998.

Automobile manufacturers contacted:
BMW, Daimler-Chrysler (Stuttgart), MCC, Audi, VW, VW Light Trucks, BMW M GmbH, Seat, Sogedac[157], Volvo, Ford, Skoda, Opel, Porsche, Renault, Fiat and the operating Japanese companies (Nissan, Honda and Toyota) were contacted.
All in all, 37 people (senior management, middle management at the relevant departments) were contacted to participate in the investigation (see Appendix A, External Questionnaire). The respective senior staff members of the relevant strategic departments within the technical and purchasing functions as pointed out under Chapter 3.3 formed the target persons of the survey. Staff at lower levels were also contacted in order to verify possible different trends within one company.

Due to the fact that any written survey frequently entails a number of problems in respect of method[158], particular emphasis was placed on the elaboration of the questionnaire. As already mentioned, most of the data were compiled by conducting a written survey using a standardised questionnaire.

Participating automotive manufacturers:
BMW, DaimlerChrysler (Stuttgart), MCC, Audi, VW, VW Light Trucks, BMW M GmbH, Seat, Sogedac, Volvo, Ford, Skoda, Opel, Toyota and Honda-UK did not participate in the survey, but sent back detailed information about their supplier development strategy. Two other European OEMs did not participate either. One of them stated that the requested information is governed by corporate confidentiality and can thus not be published. A total of 14 representative questionnaires were sent back (see Table 6.1). All of them, except one, were from

[157] Sogedac is the purchasing organisation of PSA
[158] See Nieschlag, R./Dichtl, E./Hörschgen, H., Marketing, 1988, p. 68; and Meffert, H., Marktforschung, 1986, p. 38

the senior management level. Personal interviews were conducted with 8 people to get further detailed information about interpretations, opinions, perceptions and vague statements in the questionnaire and to verify the results obtained.

Due to the political/strategic relevance, the middle management forwarded their questionnaires to the appropriate management level (senior management) in the specific departments (e.g. supplier development department, purchasing strategy departments) who signed responsible for these issues and were informed best and had an overview of the company. The relatively low number of participants reflects reality at the OEMs' and did not come as a surprise. Neither did it impair the validity of the outcomes. The fact is that only specific "central" departments at the OEMs', who are responsible for the product-/supplier strategy, have an overall view of the company and can give representative answers. As already mentioned, the selection of the persons surveyed was based on their position and respective influence and decision-making powers.

Nevertheless, 13 people from 5 different OEMs agreed to a telephone interview. The questionnaire was used with a focus on sections A 2, B 2, C 1, D 1 and D 2 as a guide for the telephone interviews. These interviews cannot be considered as representative and were not used in data analysis. However, they did reveal a few interesting aspects:

- Ranking of the future OEM-supplier relationship intensity was higher compared to feedback from the senior management level.
- They ranked fear of dependency, product/production know-how loss lower than did the senior management level.
- The statements regarding the requirements for suppliers of the individual supplier segments were nearly identical to those made by the senior management level.
- No statements were made regarding the definition of core competence.
- They expressed scepticism regarding a situation of fewer but larger suppliers.
- Ten of them have made no comment on the system-building scenario, because they did not have the necessary general overview.

The detailed results of the telephone interviews and deviations from the results of the standardised questionnaire are presented in the respective sections.

Questionnaires were received from:

NR.	Feedback from	
OEM1	* Head of Purchasing Policy and Strategy	
OEM2	* Head of Purchasing	
OEM3	* Head of Purchasing	
OEM4	* Head of Purchasing * Head of Product Strategy	(co-ordinated the questionnaire internally and sent back one)
OEM5	* Head of Purchasing / Supplier Development	
OEM6	* Head of Product Strategy and Business Development	
OEM7	* Head of Purchasing Strategy, Supplier Development	
OEM8	* Head of Purchasing	
OEM9 and 10	* Head of International Supplier Strategy * Head of Value Management * Head of Product Development (Electric/Electronic)	(co-ordinated the questionnaire internally and sent back one)
OEM11	* Head of Product Development	
OEM12	* Head of Product/Supplier Strategy	
OEM13	* Head of Supplier Development Powertrain * Head of Supplier Development Chassis	(co-ordinated the questionnaire internally and sent back one)
OEM14	* Head of Global / Forward Sourcing	

Table 6.1: OEMs' involvement

External automotive specialists has been contacted beyond the above described survey with the OEMs, in order to gain additional valuable information (i.e. crosscheck the results of the questionnaire) about the relevant topics.

Contacts with:

(i) Chief executive officer of Grammer AG[159], a major supplier of interior parts and sub-systems such as seat sub-systems, armrests, door panels

(ii) Vice President of the VDA (German association of automobile manufacturers), who is responsible for the supplier section

(iii) Senior automotive consultant at Arthur D. Little

(iv) Specialists at the RWTH Aachen (institute for development processes, especially within the automotive industry)

Special care was taken to make the questionnaire concise, simple and easy to understand. A preliminary test was conducted to this end using representative subjects in order to remedy any weak points or ambiguous questions.

The selected procurement units listed in the questionnaire certainly did not represent the entire breadth of procurement units. The units analysed were selected on the basis of their importance (A-level products) and their usefulness in

[159] Grammer AG has around 7500 employees world-wide and delivers their products to all major car companies

identifying trends toward standardisation and verifying the future scopes of systems.

The questionnaire itself consisted of 4 chapters with the first chapter dealing with general trends in connection with the supplier situation (reduction of suppliers, the trend toward more and large suppliers, potential cost savings by reducing the number of suppliers etc.).
The second chapter aimed to obtain a statement about the future structure of suppliers and the trend toward standardisation with reference to OEMs and the system-building scenario. It was intended to identify system-building standardisation trends among the OEMs based on the procurement units listed in the questionnaire. This meant finding out what was classified as a system, sub-system or component under prevalent consideration of the following points from the OEM's point of view:

- Strategic importance of the relevant unit
- Level complexity
- Content of the relevant unit considered
- Importance of a direct supply relationship
- Supplier requirements (see Figure 6.1).

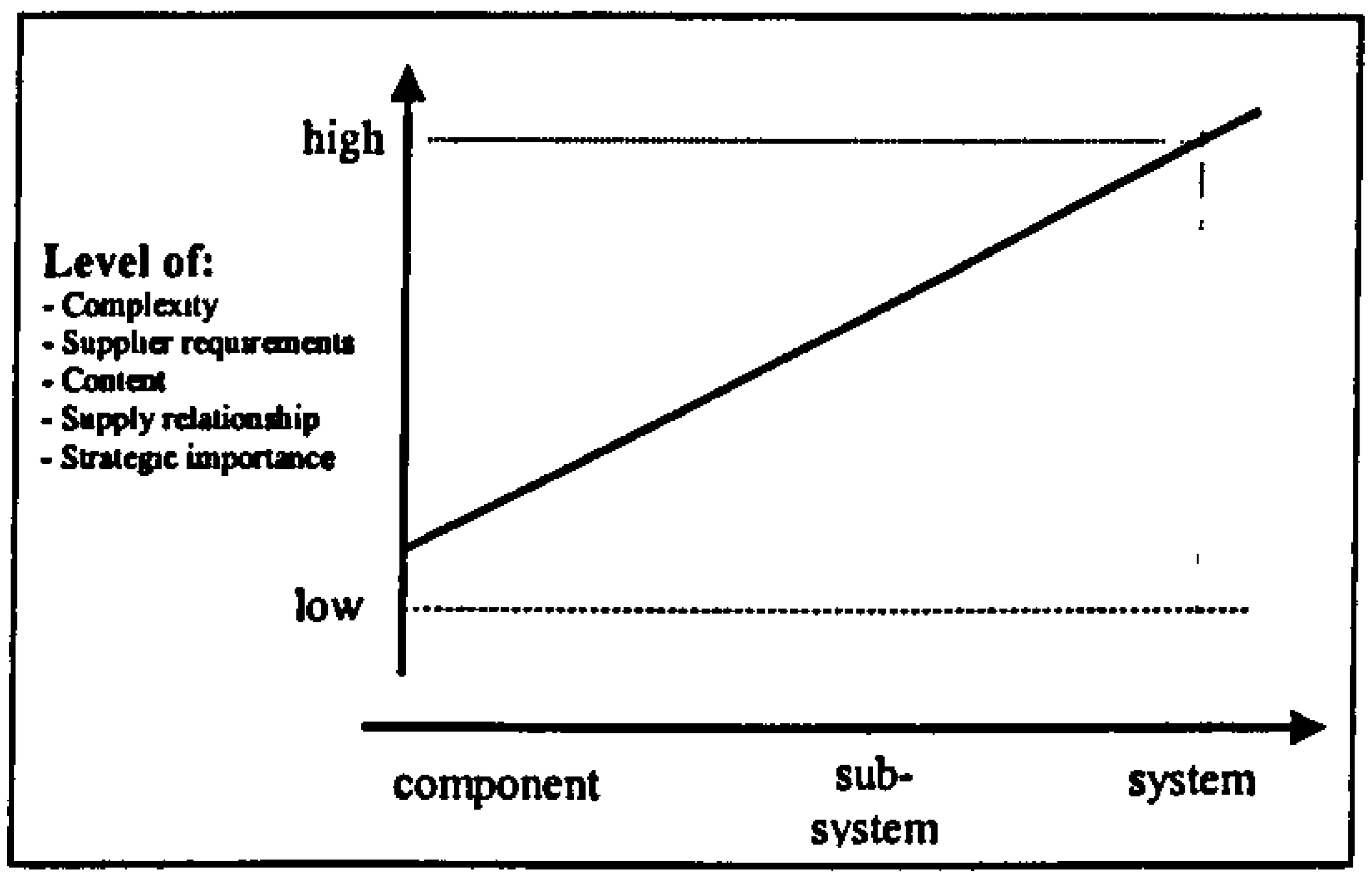

Figure 6.1: Classification factors

It can be assumed that mainly system suppliers will have direct contact with the OEMs in future, which will have a major impact on the flow of information and market position within the supplier industry and dominance in the market as a result. The term 'system' is used to cover the terms, 'system' and 'module', which are used diversely in actual practice. This results from the fact that the delimitation itself, which is not uniform anyway (please refer to Section 3.4), is not in the foreground, but rather its direct reference. This would lead one to suppose that carmakers will also be supplied directly by sub-suppliers and component suppliers in future.

The third chapter examined the diverse demands placed on the individual product segments (systems, sub-systems, components). Business-related and quality-related requirements in addition to technical and logistic requirements formed part of the investigation.

The fourth chapter of the questionnaire was aimed in particular at examining the relationship between manufacturers and suppliers. This part of the investigation focused on the future intensity of the relationships between carmakers and their sub-suppliers in the individual phases of a product's conception and development. It also took a closer look at the risks and opportunities for carmakers when integrating the supplier into the development process earlier on and more intensively. It also analysed the respective future significance and influence of mechanics, electronics and software development and asked for specific information about the system terminology.

The descriptive method and explorative data analysis were applied in the analysis. As already mentioned, the study was particularly subject to topicality, due to the fact that investigations within the motor industry in general are characterised by a highly dynamic and rapidly changeable environment.

For reasons of clarity, the results gained from the four different chapters of the questionnaire have been summarised, subdivided and presented in the two following chapters. The results of the investigations dealing with standardisation tendencies in the product segmentation scenario are presented in Chapter Six and the general changes, suppliers' requirements and the future manufacturer-supplier relationship are analysed in detail and presented in Chapter Seven in line with the context.

Visual representation of the results:
Figure 6.2 shows the form selected for displaying the system-building scenario. It intends to provide a quick and clear overview of the research results. The results reflect the summary of the statements made by the carmakers who participated in the survey. The figures indicating the basic total amount may vary due to a few double references - indication of different trends within one company - or no answers with relation to the respective procurement unit.

As shown by the fictive example, out of 14 responses for product x, 12 defined it as a system and 2 as a component. Product y was defined twice as a system, 10 times as a sub-system and once as a component.

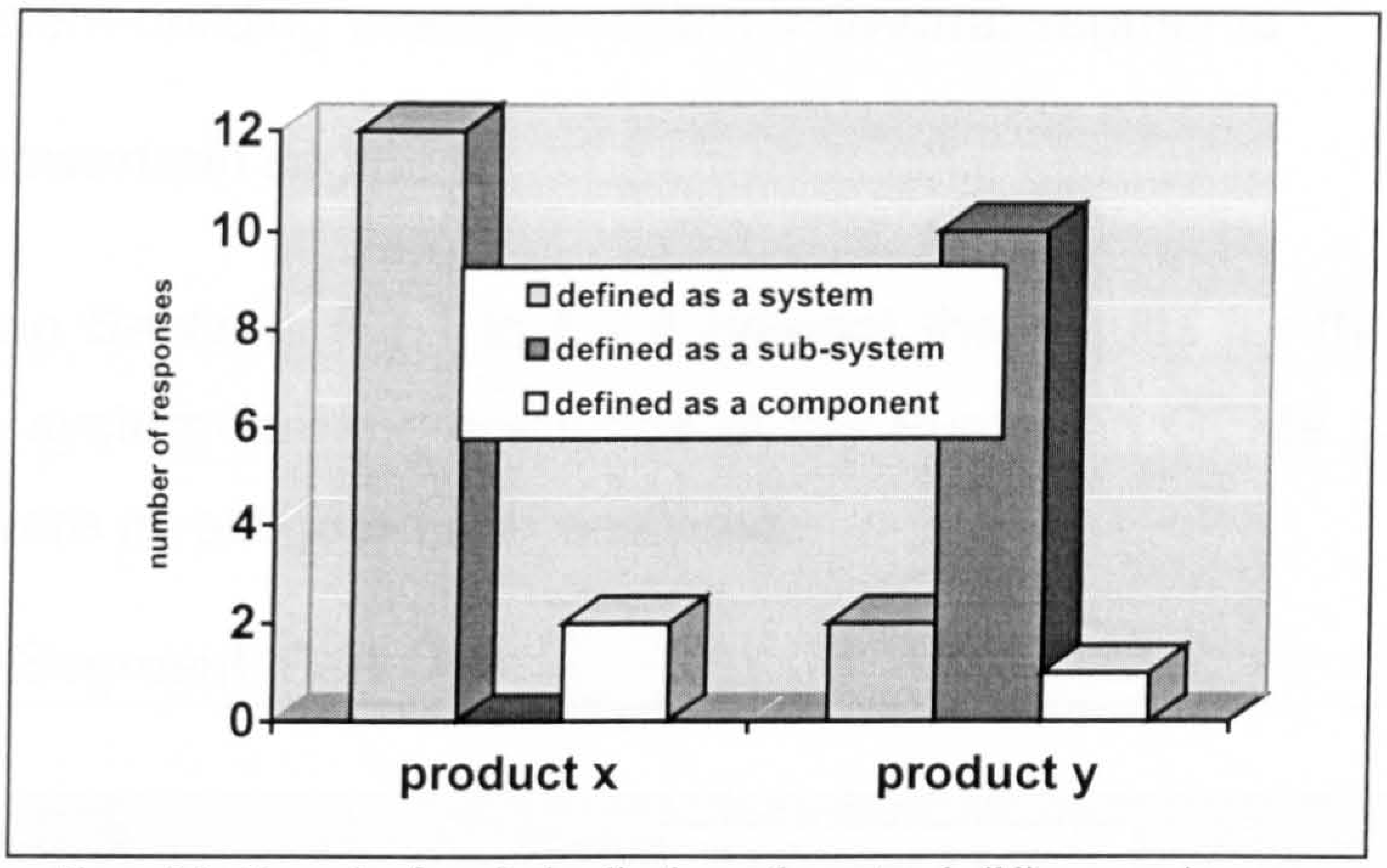

Figure 6.2: Example of result visualisation – the system-building scenario

The individual procurement units of the respective segments – powertrain, interior, suspension and exterior/body – are shown in the following with reference to their evaluation in respect of systems, sub-systems and components. The individual visual representations show the standardisation tendencies very clearly.

6.2 The system-building scenarios of the individual segments

6.2.1 The powertrain segment

The following Sections 6.2.1 to 6.2.4 present the results for the specific product units of the system-building scenarios of the European OEMs participating in the study that were investigated and analysed:

Powertrain Segment, Part One:

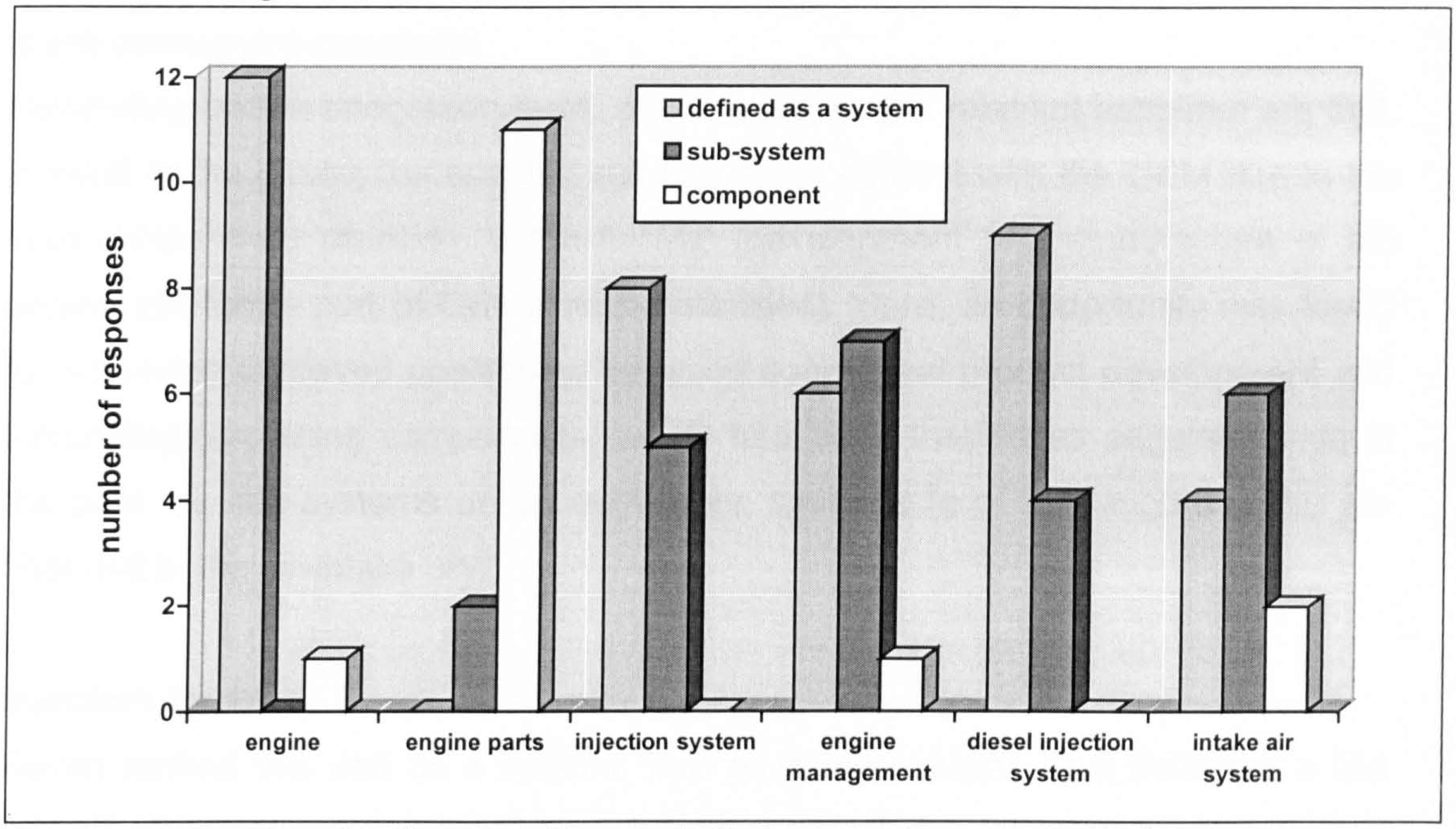

Figure 6.3 : The system-building scenario of various products (powertrain - segment 1)

Engine:

Except for one, all rated the "engine" unit as a system (twelve rated it as a system, one as a component) marked by a high rate of standardisation. Regarding the component ranking: It stems from a double reference by a manufacturer who specifies this unit as a system (in this case the engine is purchased from outside the company) as well as a component (in this case it is an in-house product). Almost all (12 out of 13) of the vehicle manufacturers stated that the engine forms part of their core competence and a large number even used them for purposes of product differentiation for marketing (e.g. VW and Audi use their TDI engine and 5-valve engine, BMW and Daimler their 12-cylinder engines and Mitsubishi their GDI to support marketing activities). Accordingly, the odds of suppliers being successful as system suppliers are very limited. Just the same, however, manufacturers may conceivably purchase engine units from outside sources toward this end in order to provide the increasing number of niche vehicles. Daimler-Benz, for example, is already purchasing transmission units from VW (VR6), which would have been inconceivable a few years ago.

Engine parts (e.g. water pump, oil filter/ oil-filter housing) :

The suppliers of these units were primarily assigned to the components segment (nine assignments). Two already ranked it as a sub-system, which may be due to a higher integration level in the cases at hand. Here, the predominant future trend is still component-orientated.

Depending on the integration level, advantages for the relevant suppliers are that, in most of the cases, the supplier still has direct contact with the OEM due to the core-competence situation at the OEMs' (development and manufacture of the engine still forms part of OEMs' responsibilities). Here, an opportunity was found for achieving improved positioning by using conceptual product development and integrating/combining components, which had been treated as separate units in the past, as sub-systems or, as applicable, systems (e.g. by integrating the air-filter unit in the air-intake unit).

Injection system:

Seven ranked this unit as a system, four as a sub-system. This indicates a low rate of standardisation (see Figure 6.4 Ranking of the injection system versus ranking of the engine) where some plan to go a few steps further in respect of

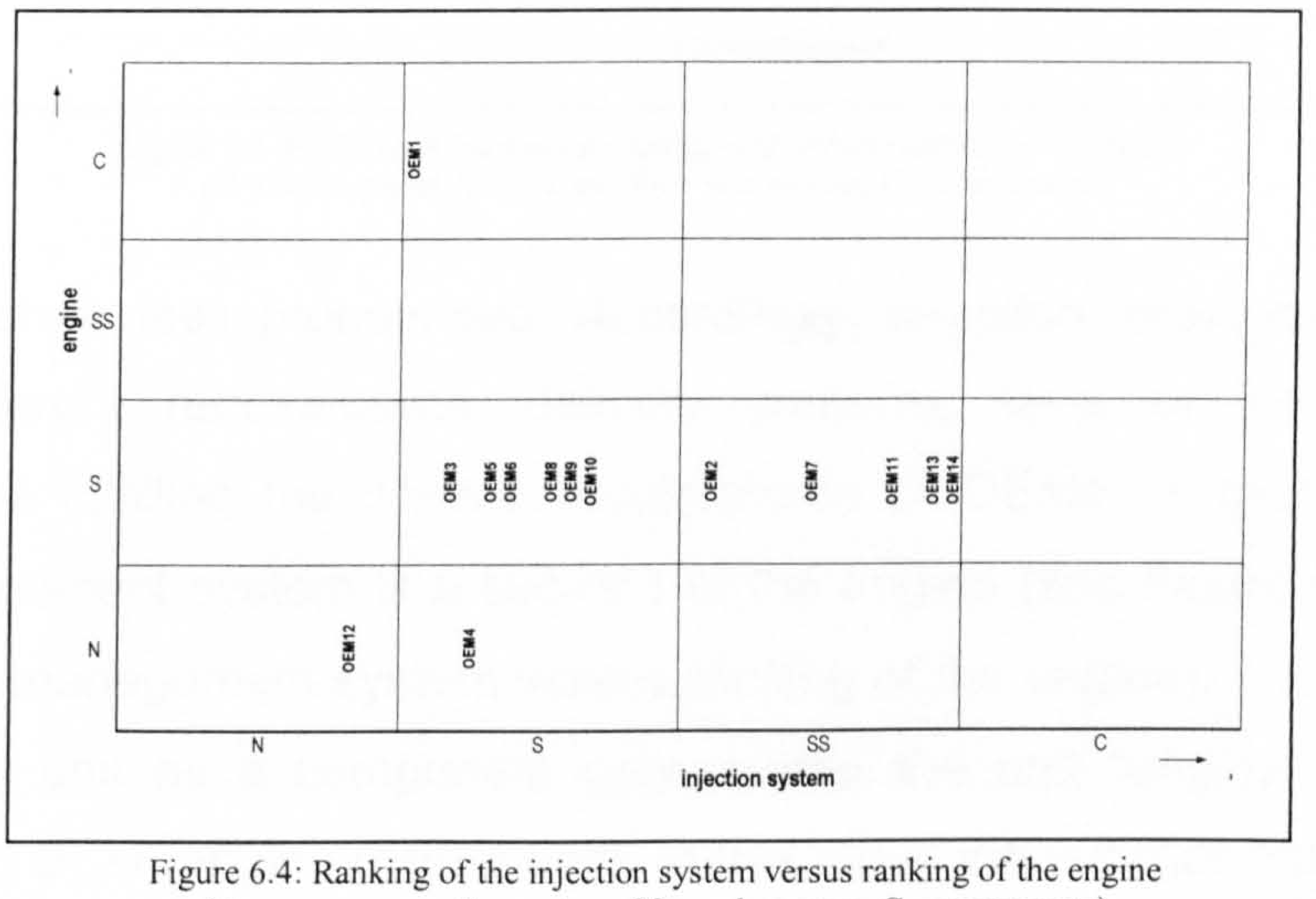

Figure 6.4: Ranking of the injection system versus ranking of the engine
(N = no response, S = system, SS = sub-system, C = component)

over-all system content, complexity, supplier responsibility and requirements, whereas others define this unit as a sub-system (sub-unit of the engine) with a lower level of the above-mentioned factors.

The fact that the majority of carmakers developed and manufactured the engine units themselves had a positive effect on the direct relationship with the OEMs irrespective of the classification. If the engine is to be out-sourced more intensively, the respective suppliers will also be placed in a position forcing them to achieve the most favourable initial position possible so as not to drop back in the hierarchy of suppliers.

Engine-management system:

Less standardisation was found here than in the "injection system" (five ranked it as a system, six as a sub-system and one as a component). The trend of

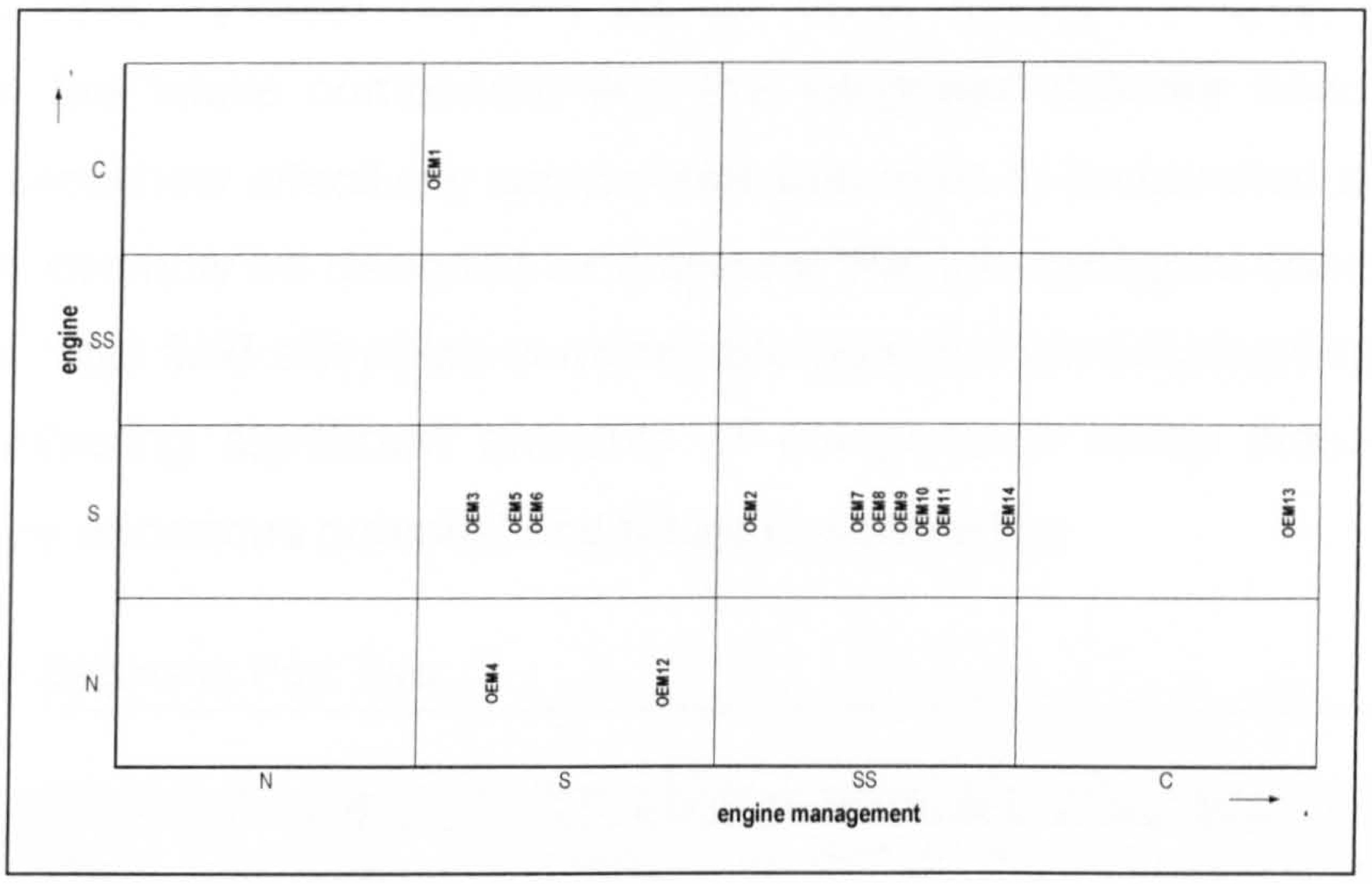

Figure 6.5: Ranking of the engine management versus ranking of the engine
(N = no response, S = system, SS = sub-system, C = component)

standardisation is less pronounced. Accordingly, suppliers must cover a broad band of different requirements, delivery contents, level of integration and responsibilities fulfilling the diverse requirements of OEMs. In most cases, the engine-management system is a sub-unit of the engine (see Figure 6.5: Ranking of the engine management system versus ranking of the engine). The person who classified this unit as a component only related the unit "engine-management system" to the ECU (engine control unit). In this case, the supplier must in fact still have direct contact with the OEM, but just acts as a parts producer without sharing a high level of responsibility where it would need to have system know-how with respect to the entire engine-management system.

Diesel-injection system:

The results for the diesel-injection unit were analogous to those of the "injection system" unit (ranked as a system 7 times and as a sub-system 4 times). The evaluations were similar with reference to the number of the relevant mentions made with reference to the respective system and sub-system segments. The statements by the carmakers were also identical.

Air-intake system:

This unit was ranked as a system and a sub-system four times and twice as a component. The truly very diverse denominations mentioned here reflect the current situation in actual practice. Whereas some carmakers are already integrating the air-intake system into an integrated air fuel system, others are still out-sourcing this unit as a component. The "integrated air-fuel system" (air filter, air intake tube, injection nozzles, control units, throttle butterfly, etc.) or, as applicable, the intake component with the integrated cylinder head cover[160] in particular show how effectively components that used to be handled and procured individually can now be designed as a system through intelligent combination and integration. This field still offers considerable potential for development. Suppliers already delivering significant amounts of components along these lines may indeed enjoy enormous potential and future opportunities.

Powertrain Segment, Part Two:

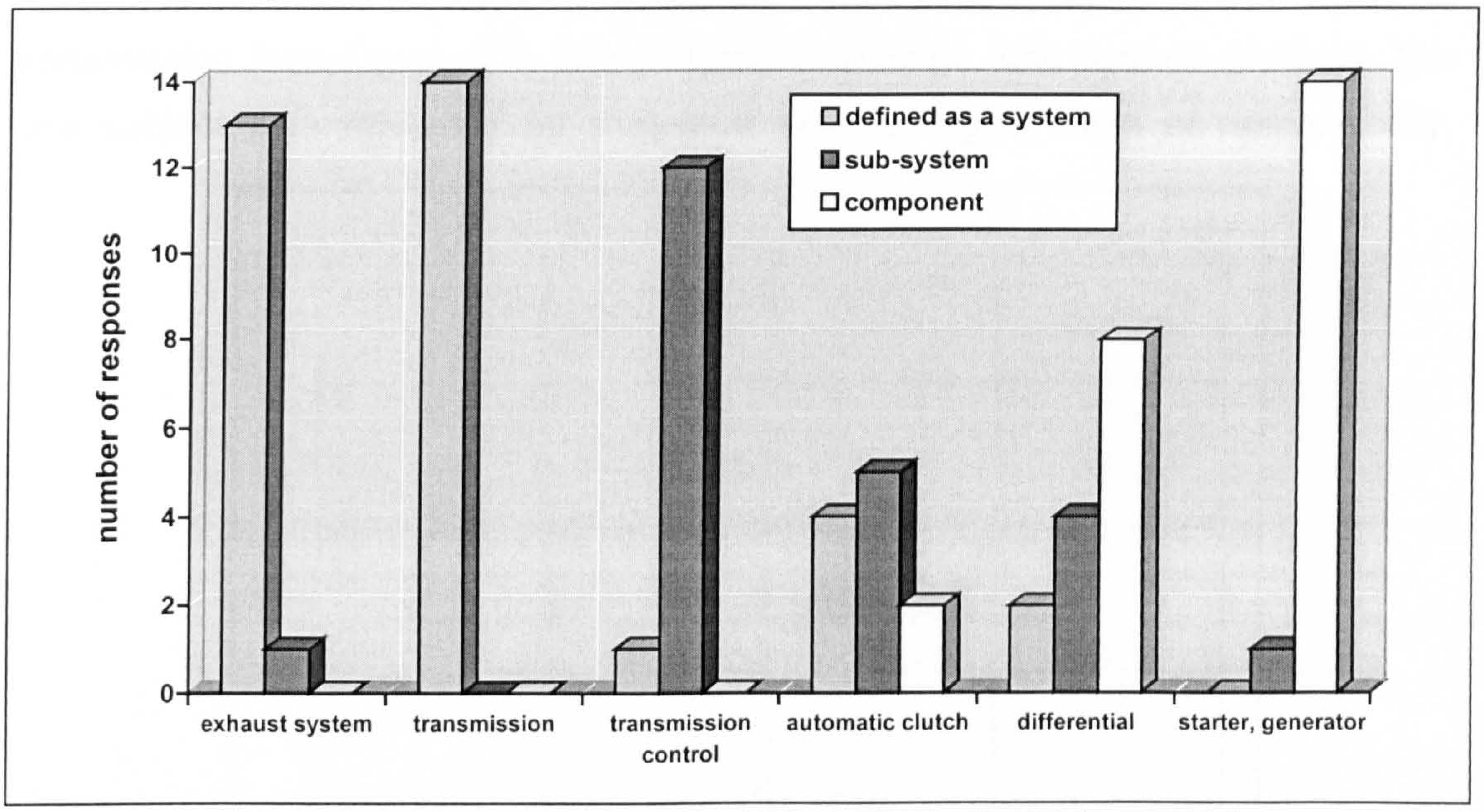

Figure 6.6: The system-building scenario of various products (powertrain - segment 2)

[160] See 3 Series BMW in: ATZ Special Edition, 1998, p. 406

Exhaust system:

Here, we find significant agreement among manufacturers (high standardisation among OEMs) in that they procure the exhaust system as a system. This is a trend-setting statement in particular for suppliers whose scope of supply used to merely encompass individual components of the exhaust unit in the past. They are in a position where they must take action in order to maintain their supplier position with reference to the manufacturer.

Transmission:

This unit was unanimously defined as a system by all carmakers (high rate of standardisation among OEMs). Due to the fact that transmission units are still predominantly developed and manufactured by the carmakers themselves (core competence of the VW Group, Daimler-Benz, PSA, Renault, Ford), the potential for being or becoming system suppliers for gear systems can be rated as negligible. Companies like Getrag and ZF generally seem to have the prerequisites, which, however, appears to be due to past circumstances more than anything. When considering the potential for success with relation to the risk involved and the potential market volume in this segment, though, the likelihood of success appears very slim.

Transmission control:

Almost all of those surveyed defined the transmission unit as a sub-unit of transmission (see Figure 6.7, 10 sub-system rankings, one system ranking). The one subject who ranked it as a system sees a higher level of responsibility,

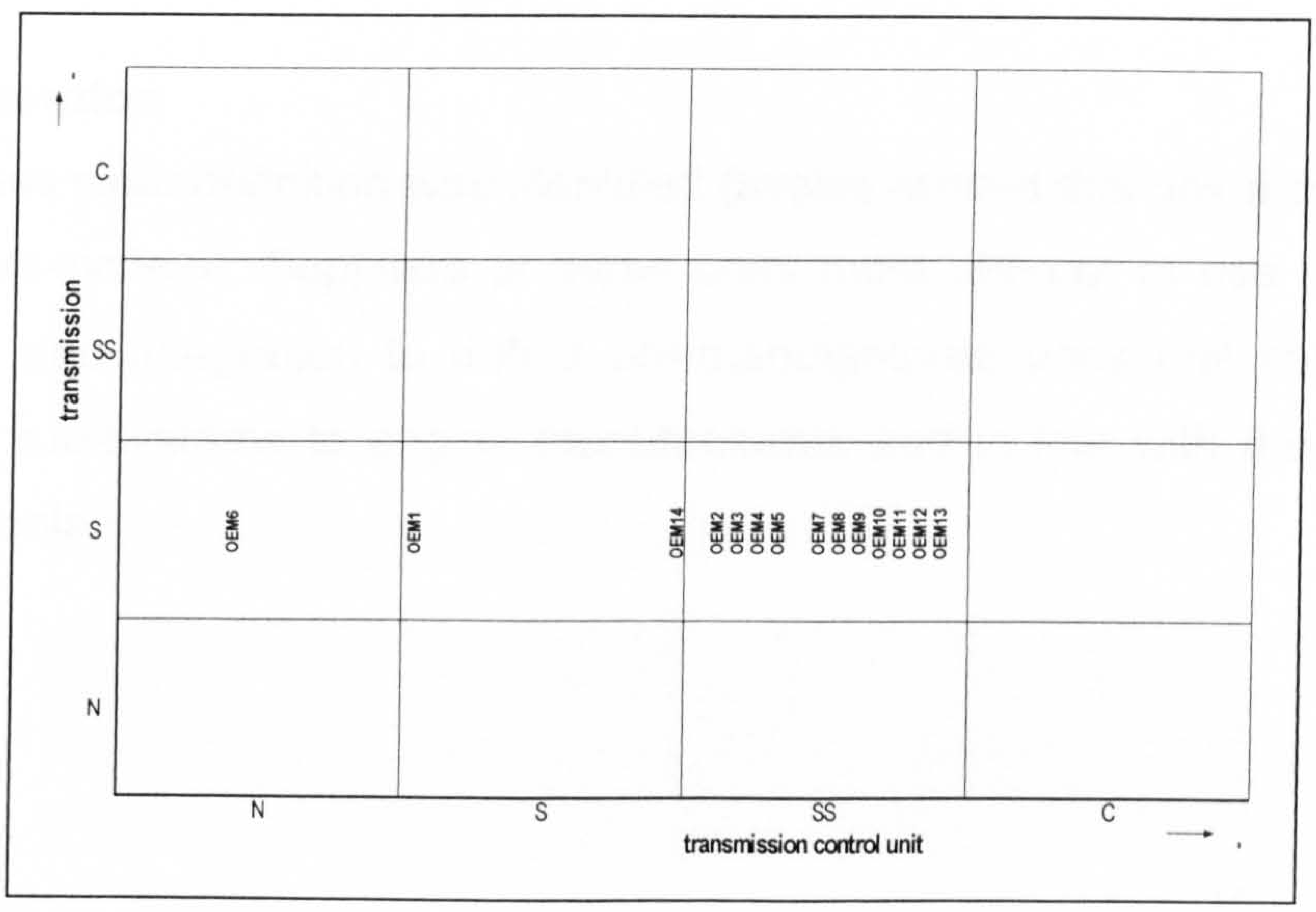

Figure 6.7: Ranking of the transmission control unit versus ranking of the transmission (N = no response, S = system, SS = sub-system, C = component)

complexity and system content at the transmission control unit supplier's due to the integration of control unit, hydraulics, sensors and actuators into one system.

Transmission control unit suppliers benefit from the circumstance that they still have direct contact with almost all of the carmakers due to the fact that a large number of OEMs develop and manufacture their own transmission units.

Automatic clutch:
The significant differences in attitude found can be explained by the novelty of this system and the fact that some manufacturers did not begin dealing with this topic until recently. Whereas three out of the ten responses received rated the "automatic clutch" as being more important and defined it as a system, eight of them defined it as a subordinate unit. Those surveyed presumably considered the transmission supplier to be the system leader.

Differential:
The inconsistency in approaches where 2 classifications were defined as a system, 4 as a sub-system and 6 as a component can be explained by the fact that one needs to distinguish between a differential in the sense of a single unit for vehicles with rear-wheel drive and differentials as an integral component of a transmission unit for vehicles with front-wheel drive. Manufacturers of vehicles predominantly equipped with rear-wheel drive defined this unit as a system. All of the other manufacturers rated it as a sub-system or, as applicable, primarily as a component.

Starter, generator:
A more or less clear definition was identified (twelve ranked this unit a component, one as a sub-system). Suppliers of these units must attempt to use meaningful combination and integration to define pre-manufactured units that can then be supplied as sub-systems to engine manufacturers and in line with the suppliers' respective goals.

6.2.2 The interior segment

Interior Segment, Part One:

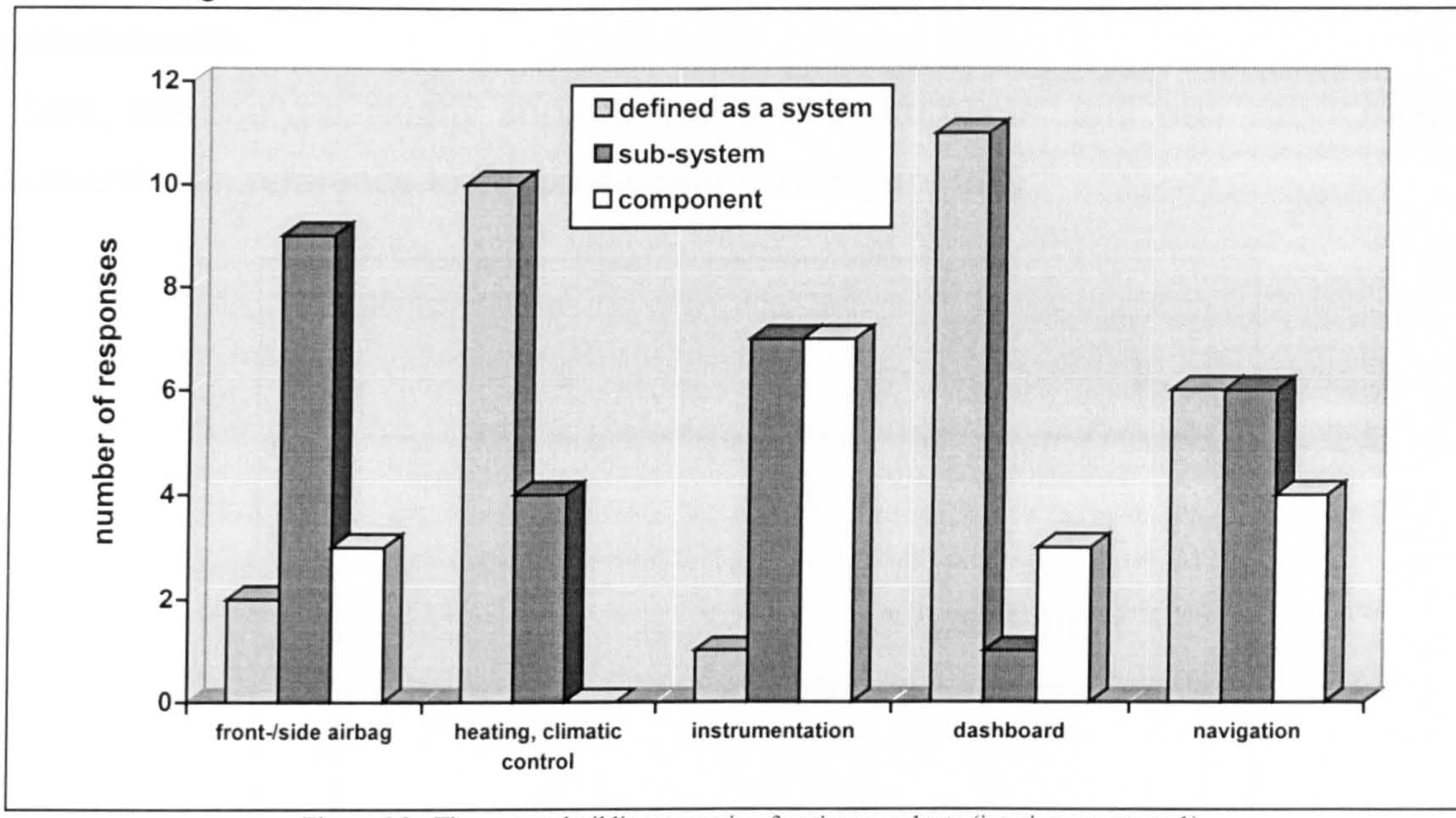

Figure 6.8 : The system-building scenario of various products (interior - segment 1)

Front/side airbags:

Most of the manufacturers viewed the front/side airbag unit as a sub-system (seven rankings) with three rankings as a component and two rankings as a system. This indicates a weak standardisation trend and a situation where the supplier is forced to meet a great variety of demands from the OEMs. If the respective unit was dedicated to the component or sub-system segment, this unit was viewed as being subordinate to the mechanical components (e.g. steering system incl. wheel, the door interior).

The electronics suppliers have already taken over as system leaders among those manufacturers who had rated the front/side airbag unit as a system due to the rising importance of electronics (software, functions) within a system. Electronics specialists in this segment in particular still have significant potential for improving their position by targeted development and expansion of their competence in mechanics.

Heating/climate control:

This procurement unit was predominantly rated as a system (eight times) and four times as a sub-system. A standardisation trend (system classification) is evident, but still not very dominant.

Two of the four rankings as a sub-system appeared to view it as a sub-system with reference to the dashboard.

Instruments:

Here, the analysis clearly showed that the "instruments" unit was considered a sub-unit with reference to the dashboard (see Figure 6.9).

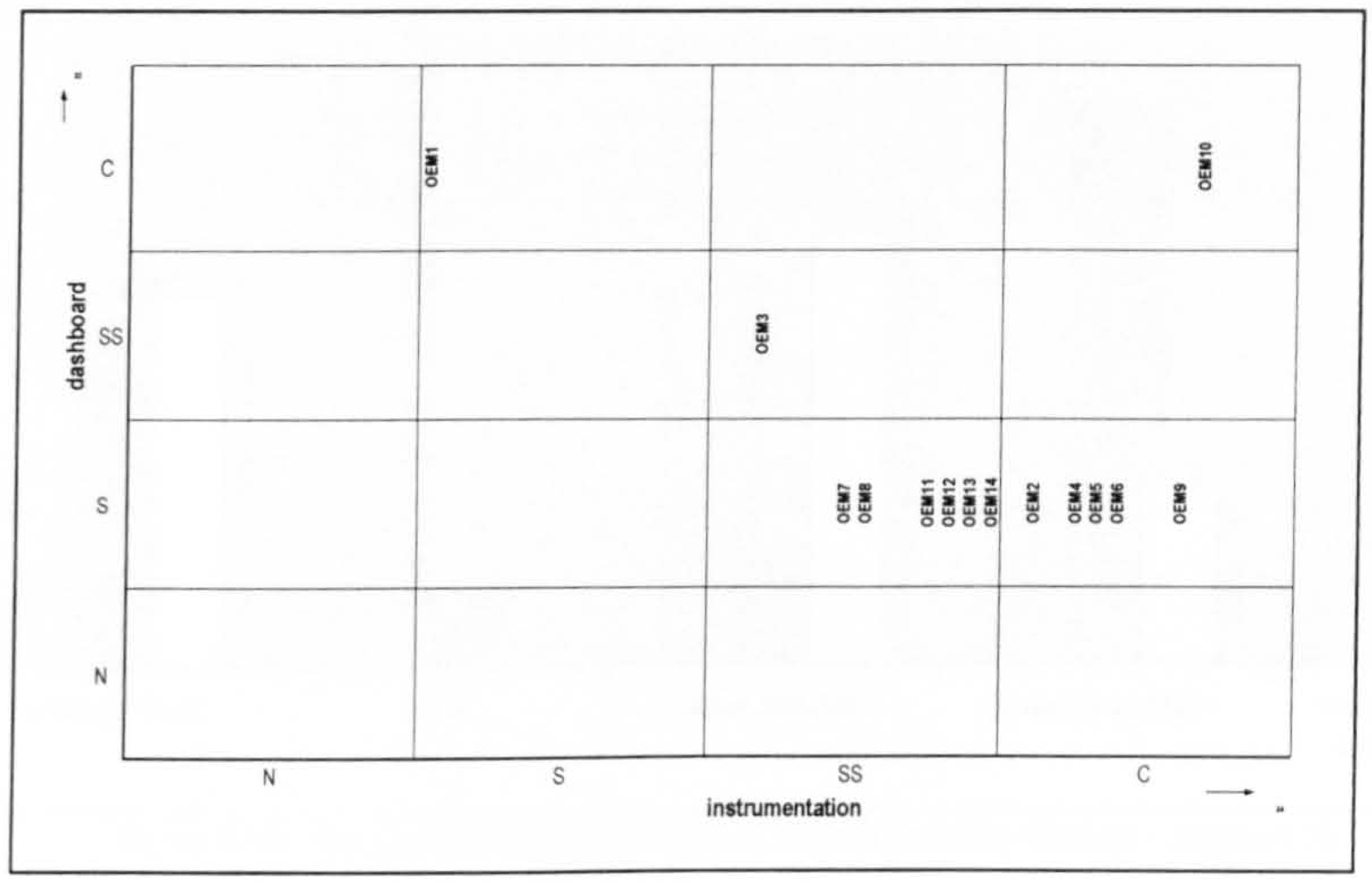

Figure 6.9: Ranking of the instrumentation versus ranking of the dashboard
(N = no response, S = system, SS = sub-system, C = component)

When a company wished to improve its status as a supplier it had to develop into a seller of entire dashboards. Granted, the centre console unit was not explicitly referred to in the questionnaire, but one can presume a similar ranking for it on account of the comparable structures (interfaces, logistics, development).

Dashboard:

The survey results showed that carmakers largely agreed that the dashboard constituted a system (strong standardisation trend). This concept is already evident in the Golf A4, the Smart, the Daimler-Benz M-Class, for example. Three of the manufacturers surveyed still rated the dashboard as a component, whereas one of the mentions was a double ranking from a company with different approaches.

Navigation:

The classification of this unit covers the whole range of possible rankings. It was rated as a system four times, as a sub-system six times and assigned to the component segment four times. Depending on the defined complexity, contents and dedicated supplier responsibility and requirements of individual OEMs, the navigation is a system or a sub-unit of the dashboard. Suppliers working in this field must adapt their organisation and processes to these different needs.

Interior Segment, Part Two:

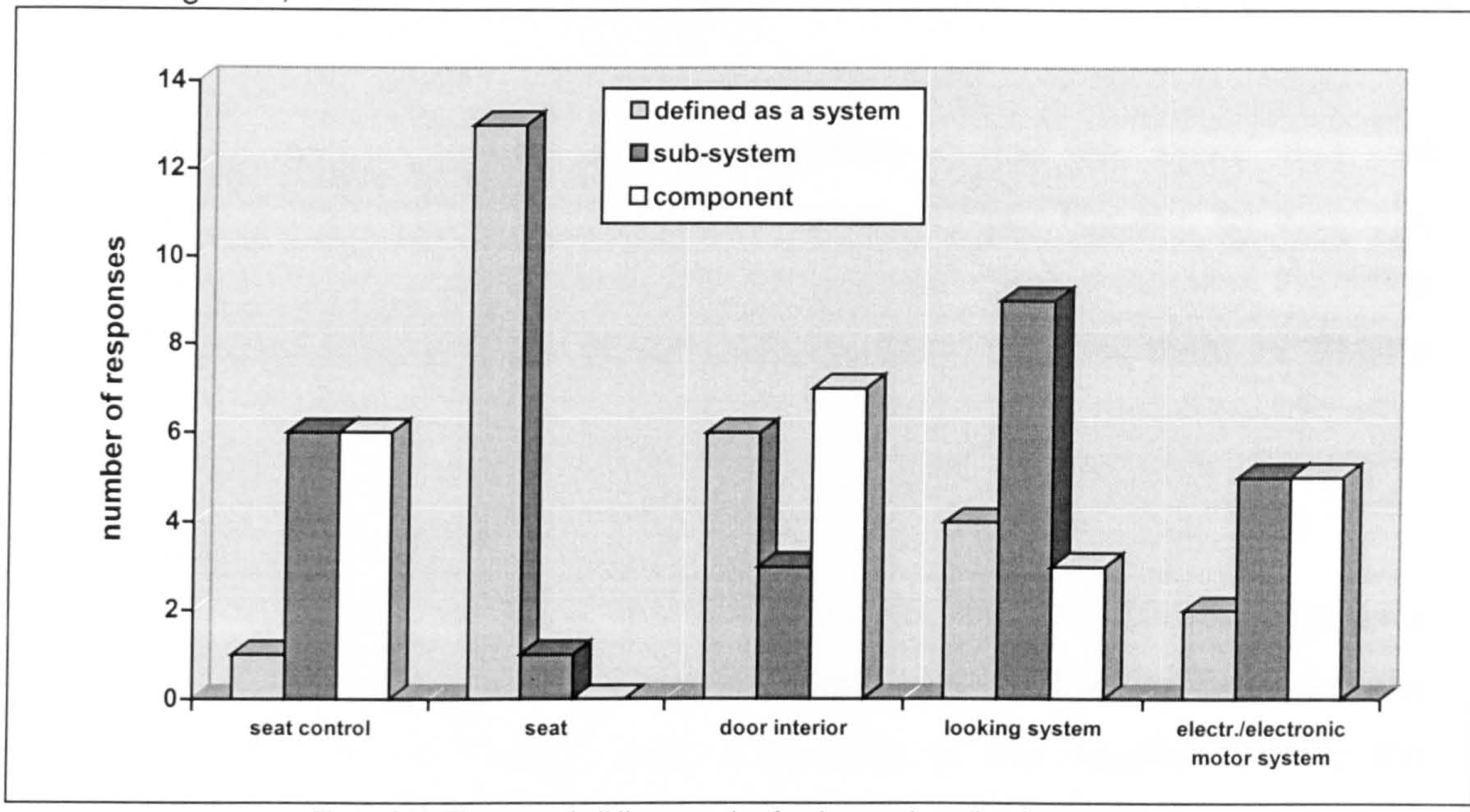

Figure 6.10: The system-building scenario of various products (interior - segment 2)

Seat control:

This unit is a sub-system or, as applicable, component of the "seat" system (see Figure 6.11).

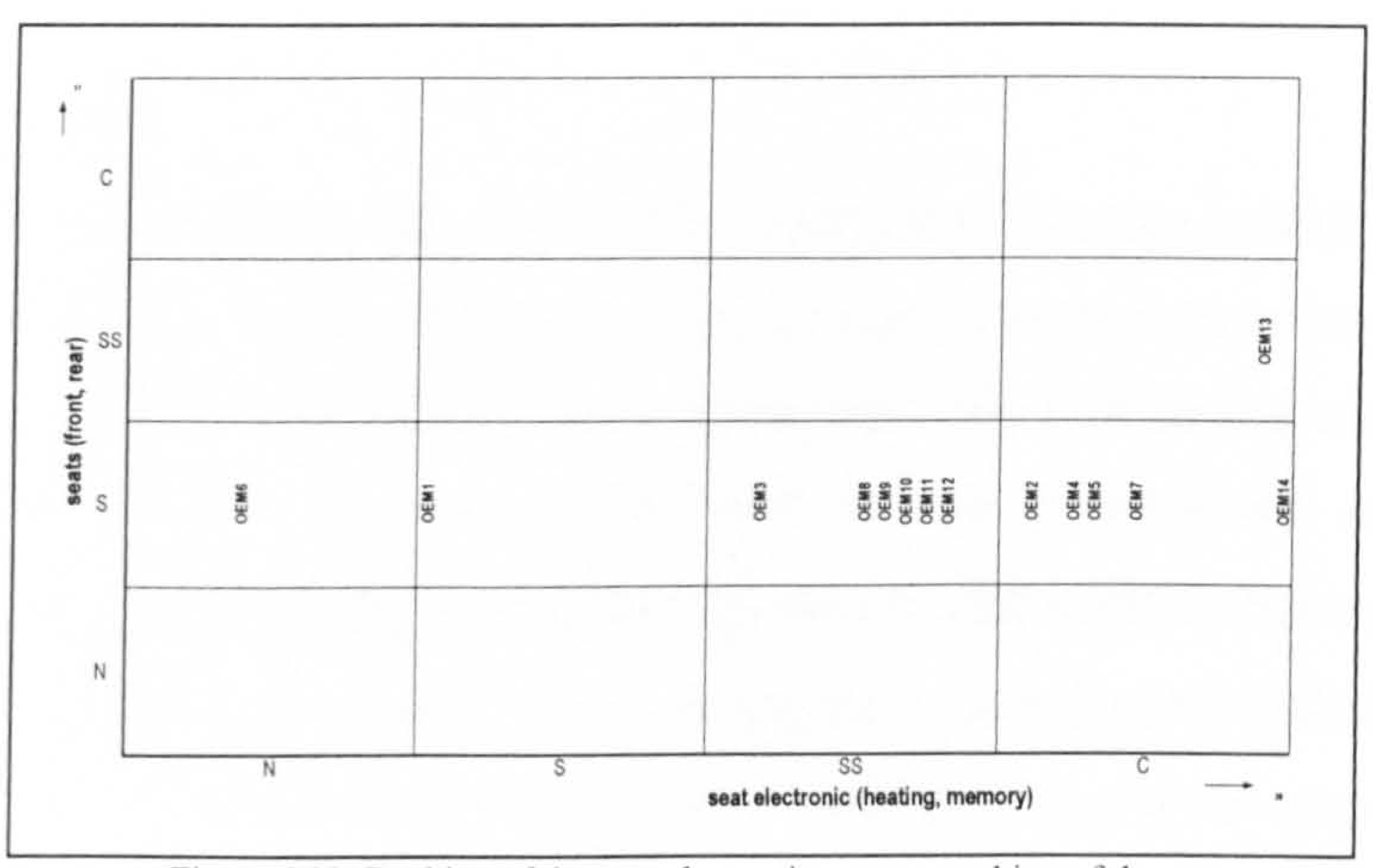

Figure 6.11: Ranking of the seat electronics versus ranking of the seat
(N = no response, S = system, SS = sub-system, C = component)

As a result of this classification, seat control suppliers are in a second-level position so that they only have very limited direct contact with the OEMs.

It is very difficult to advance to a system (seat) supplier due to the specific and extensive know-how required and the circumstance that there is already marked concentration of suppliers in this (interior) segment.

Seats:
Here, we find clear consensus among carmakers in that the "seats" unit was ranked as a system (strong standardisation trend). Keiper Recaro, for example, supplies the complete seat unit for Audi's A6, Johnson Control supplies the seats for Daimler-Benz's M-Class and Smart and Lear Corp. supplies them for BMW's Z3.

Door interior:
Carmakers use varying strategies in connection with this unit (six rankings as a system, three as a sub-system and five as a component). This indicates a weak standardisation trend and a high rate of flexibility of the supplier fulfilling the individual levels of requirements. Some OEMs are increasingly integrating and combining parts such as loudspeakers, window regulator mechanics, side airbag parts and door supports into one system, whereas many others are still adhering to the conventional method of purchasing single components and assembling them.

Locking system:
Here again, the low rate of standardisation indicates that the supplier must fulfil the individual levels of requirements and classifications with reference to complexity, content and level of responsibility. Four assigned this unit to the system segment, nine to the sub-system segment and three to the component segment. Three OEMs assigned it to two different segments due to different in-house strategies. Suppliers of this unit can improve and strengthen their position through intelligent product integration (mechanical/electronic) and development into a full system supplier.

Electrical/electronic motor system:
The results did not reveal any clear assignment. Carmakers defined and used the electrical/electronic engine systems in the most diverse of manners (low rate of standardisation). Firstly, they used them as mere drive components e.g. for

windshield wipers, window regulators and, secondly, they used them in conjunction with mechanical components as sub-systems e.g. for seats or door interiors and also as basic elements for more extensive integration solutions. The fact that the tendencies toward integration (smart actuators) in the field are only in the initial phase makes the potential for suppliers unusually high in this segment.

6.2.3 The suspension segment

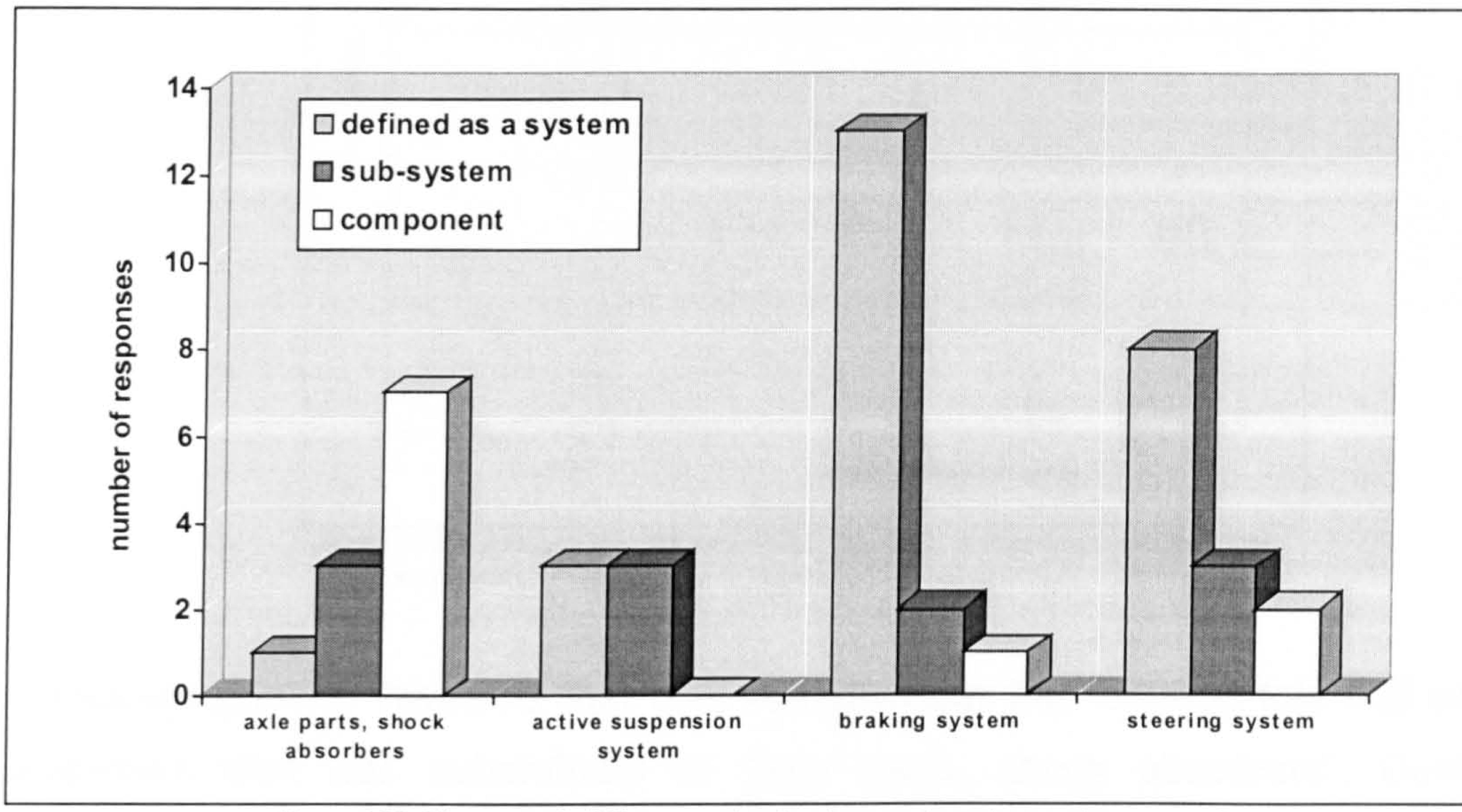

Figure 6.12: The system-building scenario of various products (suspension segment)

Axle parts, shock absorbers:

These parts were predominantly viewed as components (six rankings) and sub-systems (three rankings) despite the fact that, on one occasion, they were referred to as a system with integration of these parts in the overall chassis.

Active suspension:

The "active suspension" unit was rated as a system three times and as a sub-system three times, too. The analysis of the small number (six) of responses indicated that a large portion of OEMs do not have this system in their product range. The others differentiate between system and sub-system due to differences in classification.

Braking system (hydraulic, pipes, controller):

This segment was overwhelmingly viewed as a system (eleven times, see Figure 6.13) with the exception of one reference as a component and two as a sub-system.

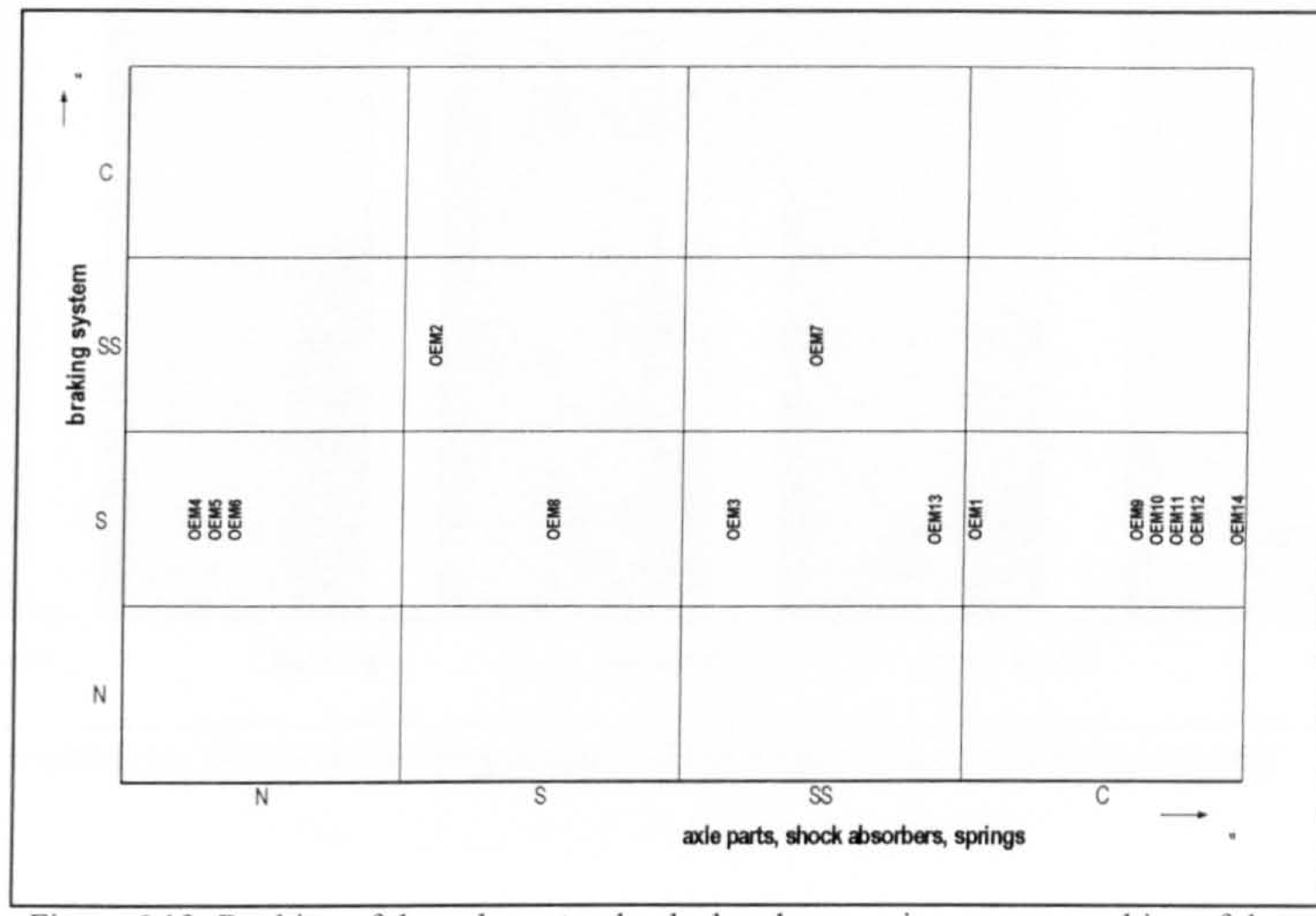

Figure 6.13: Ranking of the axle parts, shock absorbers, springs versus ranking of the braking system (N = no response, S = system, SS = sub-system, C = component)

A cross-comparison revealed that one manufacturer had defined this unit as a sub-system that was subordinate to “axle parts, shock absorbers”. Current development activities in this field are aimed at replacing hydraulic components with electronic components. This especially opens up new opportunities for electronics suppliers, who as a rule did not play a dominant role in this field or take on positions as system suppliers in the past.

Steering systems:

Results show the steering system to usually be purchased as a system (seven rankings as a system, three as sub-system and one as a component). Those who rated it as a sub-system dedicated one part of this unit to suspension and the other to the body.

Here, too, current development activities indicate a trend toward replacing the conventional hydraulic solution with electronic components and electronic engine components with the aim of improving costs, weight and functionality. Bosch and ZF have already created a joint venture that sells hydraulic, electro-hydraulic and electronic steering systems in an effort to achieve these goals.

6.2.4 The exterior/body segment

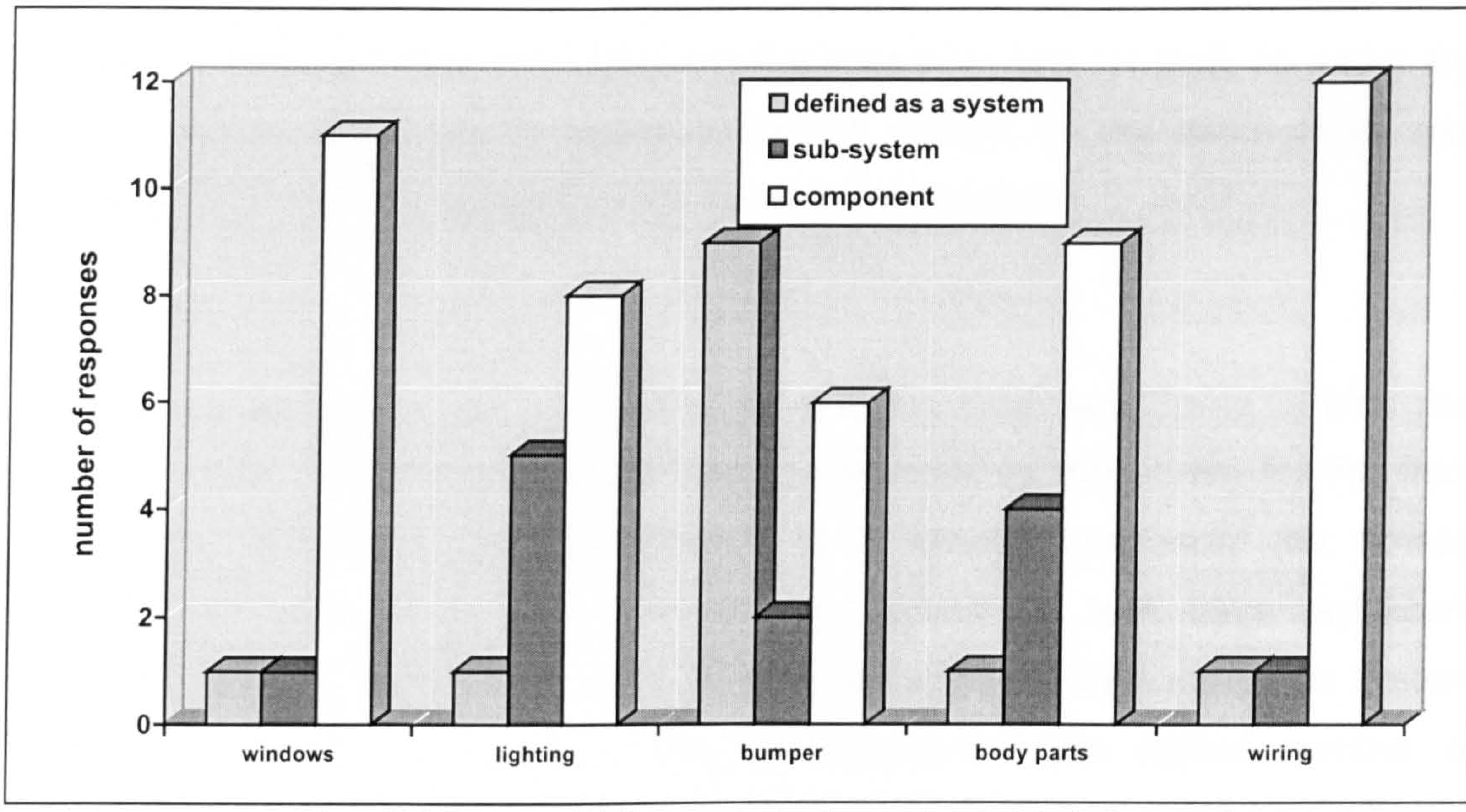

Figure 6.14: The system-building scenario of various products (exterior/body segment)

Windows:

The fact that the "windows" unit constitutes part of the doors and body was reflected clearly in the rankings. Eleven times it was rated as a component, one time as a sub-system and one time as a system.

Lighting:

The results show an identical ranking for front and back lights, so that no distinction was made between the two in the representation of the results. The

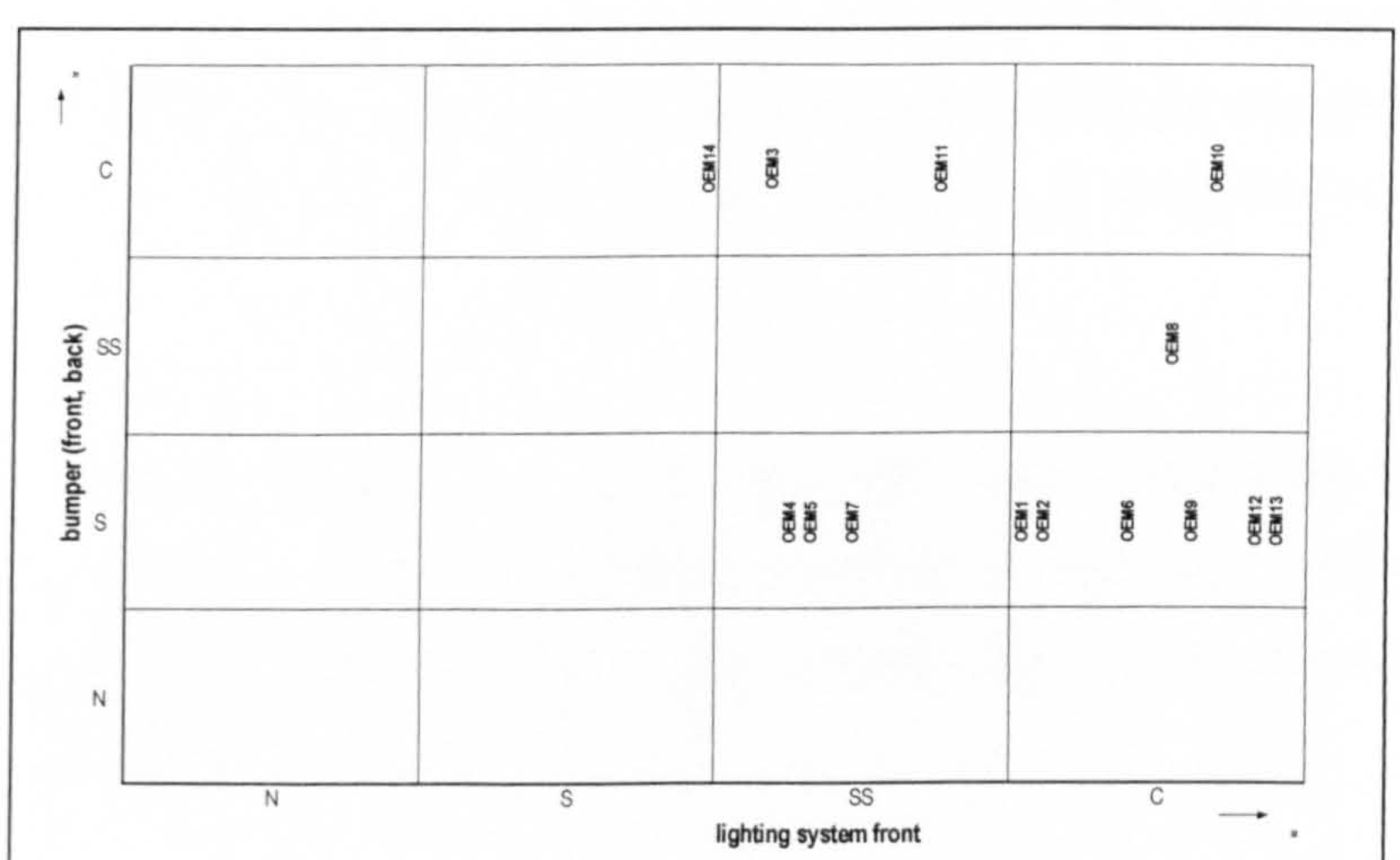

Figure 6.15: Ranking of the lighting system versus ranking of the bumper
(N = no response, S = system, SS = sub-system, C = component)

analysis showed that lighting was still predominantly viewed as a component (8 rankings), whereas other OEMs tended more toward integration and viewed this unit as a sub-system (five times) for e.g. the front end. The A4 Golf, for which the Hella company develops the overall front-end system on the basis of its core competency in the field of lights, is the best current example.

Bumpers:

A weak standardisation trend was identified with two extremes. Some OEMs rated it as a system (nine times) and defined the bumper as the centre for the front (back) end the others still purchased it as a simple component (six times). Suppliers of bumpers and of front-lighting systems as well have significant potential for developing into or, as applicable, establishing themselves as system suppliers by achieving targeted product integration. The higher number of responses resulted from double rankings where the individual OEM had different approaches.

Body parts:

Even this unit was mainly assigned to the component segment (nine times) or sub-system segment. Although there was a trend to stronger integration, no common trend among the OEMs was found. The supplier must be flexible in order to meet the different levels of requirements.

When dealing with body parts, one must distinguish between the parts belonging to the outer skin, which is developed and produced in-house with a few exceptions (e.g. Karmann, the Smart), and the body parts underneath. As regards the latter, which are predominantly out-sourced, it would be possible for suppliers to improve their position by combining individual parts in the form of complete body groups.

Wiring:

Vehicle wiring was considered a system with one exception (high rate of standardisation). This system is characterised by a high level of complexity in production control, logistics and variants management, all of which limits the number of potential suppliers.

6.3 Summary

This section aims to ascertain whether there are any tendencies toward standardisation in respect of the system-building scenario (system-segmentation scenario) within the European automobile industry. This could serve as an indication that might be of significant benefit in the course of the ongoing change processes and adjustment activities on the parts of manufacturers and suppliers.

As shown by the study results presented in the above, with a few exceptions, no distinct and clear line of future system building (product segmentation) can be distinguished among the carmakers.

The consequences for suppliers are clear: They must adapt how they handle a major portion of products to different situations in terms of procurement unit classification (for instance, the same unit might be viewed as a system in one case and as a sub-system in another) and the respective requirements. This requires a high rate of flexibility of organisational structure and processes in order to be able to adjust to extremely diverse framework conditions as rapidly as possible.

Using the powertrain as an example, we find three future systems – the engine, the exhaust system and the transmission. Here, suppliers of the relevant electronic control units and injection systems predominantly have direct contact with the OEMs due to the fact that the majority of carmakers still manufacture the "engine and transmission" units themselves. One must assume a shift of the depth of performance toward the supplier depending on carmakers' definitions of core competencies and in line with stronger tendencies toward integration in respect of engine and transmission components.

Rankings for the interior segment were even more diverse. Nevertheless, two systems worthy of mention, namely the dashboard and the seat, emerged from the study results. All of the other systems were given a wider range of rankings. There is potential for suppliers of electronic systems, driver information systems, seat control units, instruments, navigation systems and electrical/electronic engine systems to develop into system suppliers by means of targeted strategic action, i.e. by combining electronics and mechanics.

The interview with the CEO of the Grammer AG, manufacturer of head rests and centre arm rests, revealed the opinion that a supplier structure in the field of interior components, where the system supplier is the only one to still maintain direct contact with the carmaker and to assume overall co-ordination of the sub-suppliers will not be fast in coming, should it even develop at all. The following grounds were given:

- Structures and relations that can be traced to the past and have grown over a period of many years.
- OEMs' fear of having too much power concentrated in a single supplier

This statement was confirmed by the responses from the automobile industry. However, the acquisition activities observed indicate quite the contrary. According to A. FEIGE, Arthur D. Little, the tendency toward concentration among suppliers of interior components will continue, even though the term "mega-supplier" is not a popular one in this sector.

Accordingly, the following take-overs have taken place, which indicates clearly the supplier concentration within this area:

- ECIA took over the seat manufacturer, Bertrand Faure, who had previously taken over RHW and Technocomfort,
- Magna took over the Douglas and Lomason company and Ymos' exterior and interior divisions,
- Lear recently acquired Maisland, Keiper Seating, Carlisle and Automotive Industries and
- Johnson Controls took over Prince, Roth Frere, Inoac and, most recently, Becker-Happich[161].

The results for the suspension segment also indicate limited tendencies toward standardisation. There is a trend here to purchase entire axle units or suspension units[162] that is not revealed very clearly by the existing results. As regards classification of the "braking and steering system" units, X-by wire activities (brake-by-wire, steer-by-wire, etc.) have caused a wide market that used to be dominated by the mechanics sector to open up for manufacturers of electronic parts.

[161] See Feige, A., Nur noch acht Systemintegratoren, in: Automobil Produktion, June 1998, p. 90

[162] See Daimler Benz (now DaimlerChrysler) M-class, complete suspension units for the front and rear axles will be supplied by ZF

The exterior/body segment presents a similar picture. The “wiring” and “window” units were rated clearly, whereas the other ones were given differing classifications. The fact that the “bumper” unit was purchased as a system allows the conclusion that this can be viewed as a basic unit for front ends.

Chapter Seven: General changes concerning the future OEM–supplier relationship and requirements for the individual supplier levels (system, sub-system, component).

This section uses the groupings of system, sub-system and component suppliers as a basis for presenting and analysing the requirements of the individual segments. It also presents the general changes and viewpoints identified at automobile manufacturers in descriptive and explorative form with reference to changes in the supplier structure, procurement landscape and future relationships.

7.1 General changes and expectations

7.1.1 Total number of suppliers

The study confirmed a clear trend toward a reduction in the number of direct "system" suppliers within a changing supplier structure (pyramid form) in which only a few suppliers have direct contact with automobile manufacturers. This was related to statements to be found in the literature[163]. The values presented in Figure 7.1 indicate a reduction in the number of suppliers down to a third of the current volume. Bernd Pischetsrieder once stated (1993) that, although he essentially rules out that BMW will have fewer than 800 suppliers one day, he does strongly believe that only system supplier will have chances of success. According to Lopez, former Head of Production and Purchasing at VW, VW will work with just 200-300 direct suppliers who are the best in the world[164]. Even Valeo chief, N. Goutard, expects half of Europe's suppliers to disappear by the year 2000[165]. The people participating in the telephone interview merely used qualifying statements rather than figures to express their sceptical view that the supplier base will be reduced excessively to the effect that fewer and larger suppliers will dominate the situation. Although they were aware of the additional effort necessary for handling

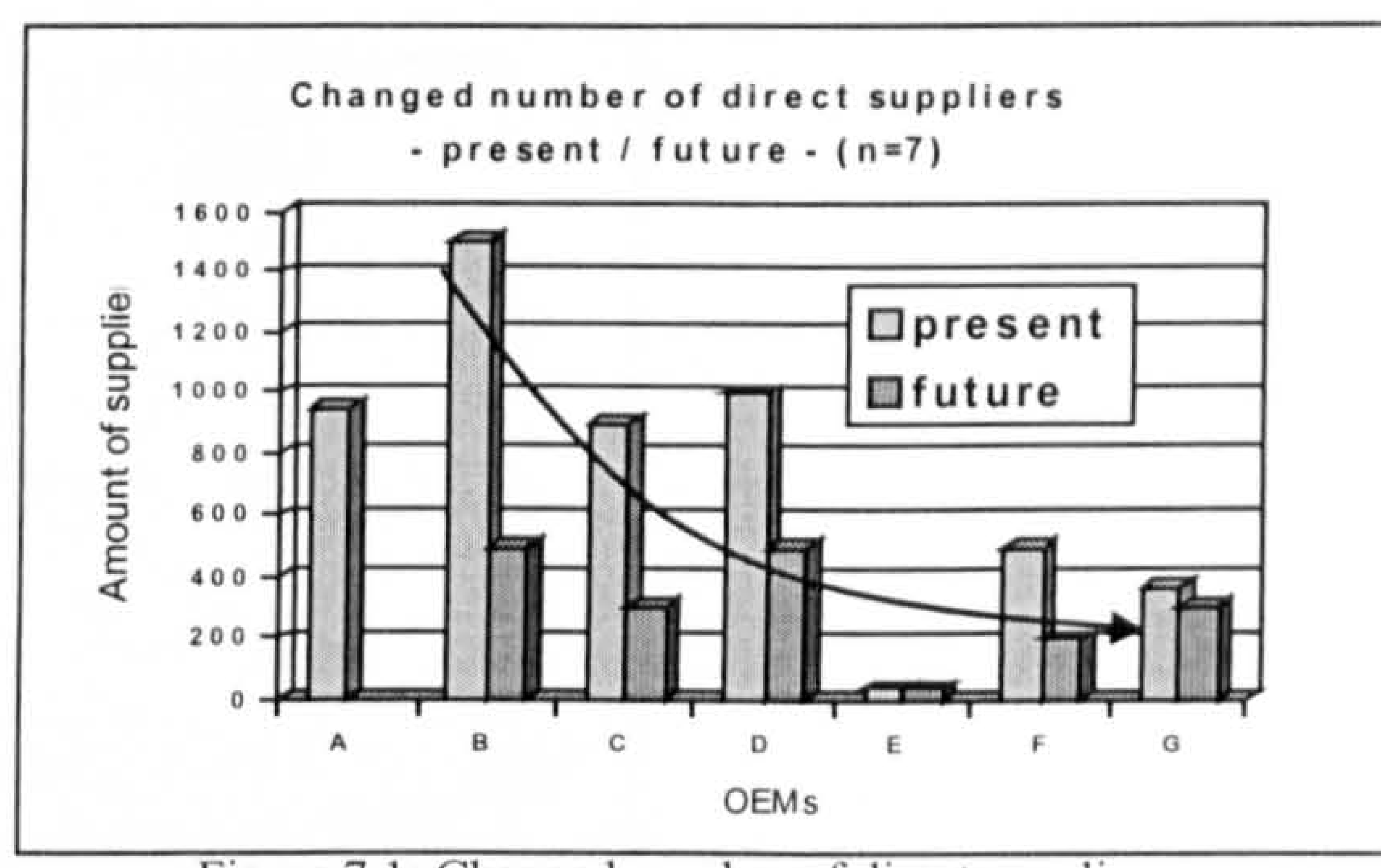

Figure 7.1: Changed number of direct suppliers

[163] See Glöckner, T., Großer Sprung, Wirtschaftwoche No. 7, 1996, p. 37; Becker, H., in: Automobil Produktion, No. 6, 1996, p. 22; Lamming, R., 1994, p. 234; and Esebeck, von, G./Reif, R./Stuwe, C., Supplier co-operation a way to become a system supplier in the automotive industry, Isata-Proc, 1996, p. 430

[164] Lopez, I. (Interview), Wir haben die besten Zulieferer der Welt, in: Automobil Produktion, Sept. 1994, pp. 28-29

a larger number of suppliers, they assumed a negative impact on flexibility and innovation due to this trend. They were more concerned about this effect than the other ones.

Merely taking a look at LAMMING's typical profile of a group of suppliers in mass production makes clear that it is economically essential to reduce their number[166] without taking into account the reduction in suppliers automatically resulting from system building. According to LAMMING, the "tail area" of the curve shown in Figure 7.2 can be found at all major automobile manufacturers. In this case, it is clearly possible to talk about waste, since purchasing departments are forced to perform a number of co-ordination activities and maintain contact with suppliers who only account for an extremely low proportion of the purchasing volume.

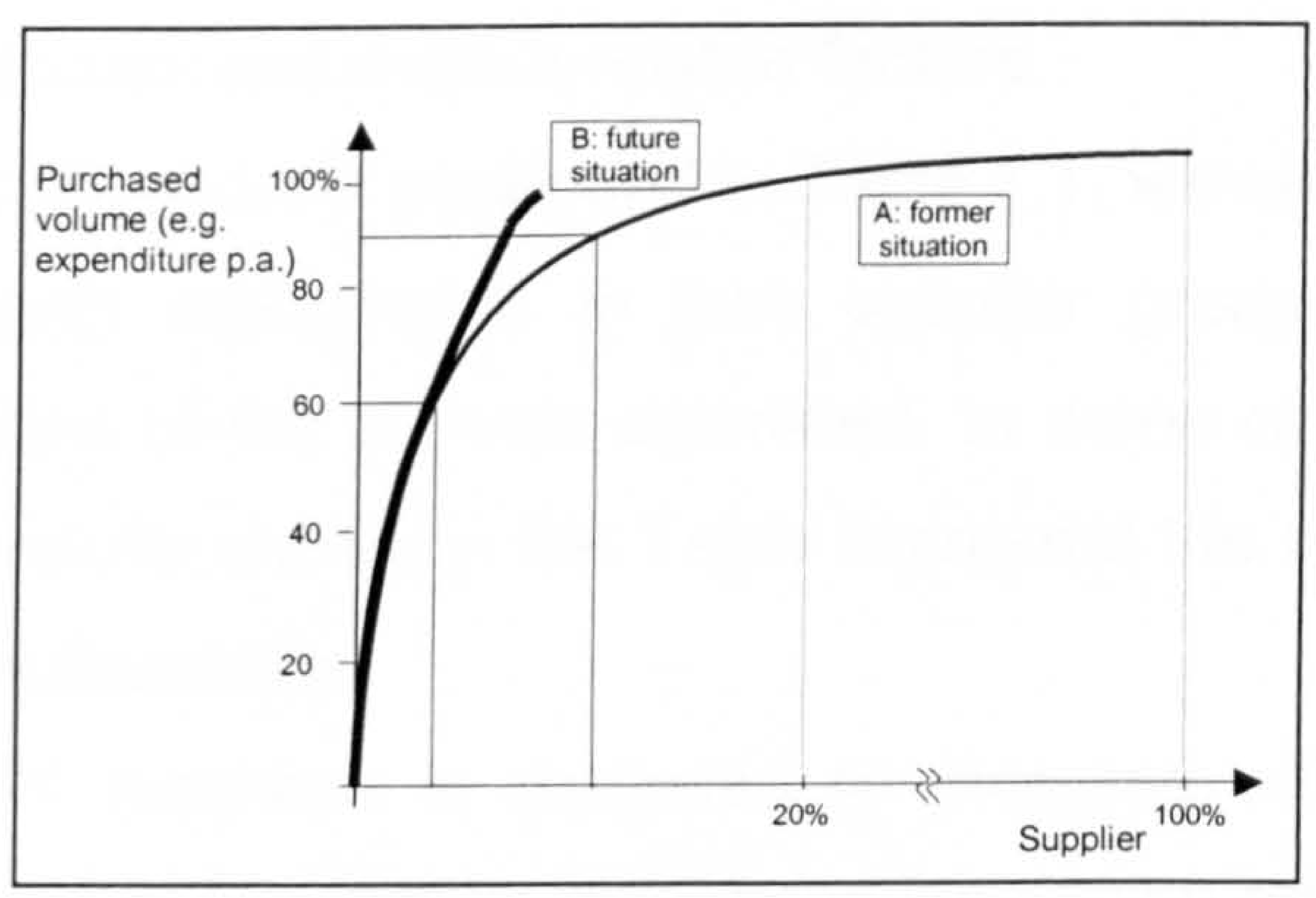

Figure 7.2: Purchased volume per supplier past - future
(source: Lamming, Die Zukunft der Zulieferindustrie, 1994[1])

A tail area can also be found in the supplier group of lean producers, although this would be much smaller. In his investigations, LAMMING names two main reasons for the existence of such tail areas:

"- The companies positioned there are the only available supply sources for the parts or materials concerned. The manufacturer would like to purchase these articles from one of his larger suppliers, but is unable to.
- The suppliers with a low order volume are kept in order to allow a price comparison with major suppliers (as a weapon, as it would be called in the terminology of traditional negotiations)."

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165 Report Deutscher Wirtschaftsdienst, Internationalisierung - Chancen und Risiken für die Zulieferindustrie, report No. 46, p. 37

166 At DaimlerChrysler (Stuttgart) e.g. 50% of the procurement volume was supplied by 40 suppliers; 360 suppliers already covered 95% of the procurement volume and the rest was distributed among 850 suppliers, in: TopBusiness, Sept. 1993, p. 24; see also, Remmel, M., Ein Blick über Tandem hinaus, Automobil Forum

The apparent pragmatism of this reasoning has ensured the survival of tail areas up to now. The challenge now facing suppliers is to actively influence the reduction in the number of suppliers and to make sure that a large share of the volume is distributed.

7.1.2 Improvements as a result of supplier reduction

As automobile manufacturers have certain expectations regarding the reduction in their supplier volume and the literature has primarily concentrated on the cost aspect, it was interesting to find out what potential improvements manufacturers associate with a reduction in suppliers. Based on the magic action rectangle used by HOFMEIER R.[167], the study focused on economic aspects in addition to qualitative, technological and market-related factors.

If we take a look at the results presented in Table 7.1, we can see that automobile manufacturers expect adjustments in their supplier group to result in 20-40% improvement in terms of the aspects examined. In some cases, expectations are even higher. The values shown in the Table represent the numbers of responses by automobile manufacturers.

A smaller group of suppliers is expected to increase efficiency considerably, especially with regard to flexibility (point D) and innovation rate: "Less is more".

When these figures are compared with the values for collaboration models - POZ, Tandem, Pole, KVP, DFL, PICOS (see section 4.3.1.3), - it becomes clear that potential for improvement and prospects of a reduction in supplier volume are rated higher than collaboration model methods.

	Expected **improvements** [in %] by reducing the number of supplier (the values indicate the number of responses)					
	0%	20%	40%	60%	80%	100%
A) Cost reduction (n=10)	1	6	2	1	0	0
B) Time to market will improve (n=10)	0	3	4	2	1	0
C) Reduction of co-ordination efforts (n=11)	2	1	5	1	2	0
D) Reaction time to market requirements (n=10)	0	2	5	1	2	0
E) Innovation rate will improve (n=10)	0	1	4	3	1	1
F) Quality improvements (n=10)	0	4	4	2	0	0

Table 7.1: Improvements OEMs can expect as a result of the decrease in supplier

[167] See Hofmeier, R., Wertschöpfung aus Winner-Positionen, in: Absatzwirtschaft, April 1993, pp. 60-69

Suppliers, who, following the process of selection, have managed to remain among those with business contacts to the automobile manufacturer, now have to live up to these great expectations. The improvements hoped for will not come about simply by reducing the supplier group. A new, more streamlined and more powerfully structured environment is also necessary.

7.1.3 Observations on the system approach

The automobile manufacturers who took part in the study were asked to comment on the questions listed in Table 7.2 in order to enhance understanding of the future system landscape and supplier structure or partnership relationship between the manufacturer and supplier. Again, the figures in the individual cells represent the number of responses.

	Yes	No	No statement
A) The definitions of "system" and "sub-system always depends on the vehicle concept and the definition of the interfaces (n=13).	11	2	0
B) It is not mandatory for the system supplier to have detailed product know-how (n=14).	3	11	0
C) The main task of the system supplier is to combine the sub-systems and components into one unit and deliver the unit JIT to the OEM (n=14).	6	8	0
D) Only the system supplier will be involved in the product development process intensively and at an early stage. The system supplier will be responsible for integrating the sub-system/component supplier into the development process (n=14).	8	5	1
E) We will have close and direct contact with all supplier level, altough we will reduce the overall number of contacts (n=14)!	7	4	3

Table 7.2: Observations on the system approach

If we take a very general look at the results, we notice that, alongside the increasing networking of systems in the vehicle, co-operation between manufacturer and suppliers in the form of network structures is also becoming increasingly apparent. In networks, co-operation between the companies concerned does not adhere as strongly to the stricter pyramid-shaped hierarchy. Once again, the manufacturers are primarily in contact with the system supplier, but still involve sub-system and component suppliers in the direct contact processes. This corresponds with the Japanese model of a supplier pyramid that is supplemented by sub-system and components suppliers who supply directly to manufacturers. WILDEMANN[168] refers to this as a European keiretsu. This assumption is substantiated by the statements made in response to questions D

[168] See Wildemann, H., Optimierung von Entwicklungszeiten, 1993

and E. Although the majority of manufacturers maintain that close and early involvement in the development process will only apply to system suppliers in the future, almost as many did not agree. If we then include the responses to question E) "We will have close and direct contacts with all supplier levels, although we will reduce the overall number of contacts" - in our observations, it becomes clear that a supplier landscape/system landscape will ultimately not be realised.

The results also make it clear that the assembly of sub-systems and components to form a system on the basis of existing production know-how and significant process innovation is not enough to make a system supplier. In view of "black box" developments or stringent specifications on the part of OEMs, a suitable level of development and innovation potential is expected in order to be able to produce solutions and innovative concepts independently. This is exemplified by the answers to question D) "Only the system supplier will be involved in the product development process intensively and at an early stage. The system supplier will be responsible for integrating the sub-system/component supplier into the development process." and question B) "It is not mandatory for the system supplier to have detailed product know-how."

The clear response made by manufacturers to question A) "The definitions of \`system\` and \`sub-system\` always depends on the vehicle concept and the definition of the interfaces" is an indication of the dynamics which can affect this branch of industry. The system-building scenario may look quite different for following vehicle generation concepts or subsequent vehicle generations related to the system-building scenarios that have been analysed and presented (see Chapter Six), which covers a time frame of 6-8 years. This presents a challenge to suppliers in terms of flexibility and adaptability.

7.1.4 Observations on the future importance of mechanics/electronics

If we take another look at Figure 5.14, "Innovation waves...", and Figure 5.15, "New systems", relating to the automobile industry (Section 5.2.4), we find a clear indication that whereas the number of new vehicle systems is rising, electronics will play an increasingly important role in the future. It should be noted at this point that the increasing demand for comfort and conveniences, safety, noise reduction, exhaust emissions and reduced fuel consumption is most likely to be met with the aid of highly complex electronics.

Whereas in the past, mechanical principles were used to find solutions and satisfy requirements, e.g.

- Better comfort of ride: With McPherson struts, multi-link axles, use of sub-frames, self-levelling suspension (hydraulic/pneumatic)
- Enhanced performance: Use of compound carburettors, turbochargers, G-supercharger, modified cam shape, torsion differentials, viscous couplings
- Improved safety: Procon-ten system, impact absorbers, new materials, seat-belt systems,

the use of electronics has rapidly increased over the years. This can be attributed to the tremendous progress in microprocessor technology. Electrical/electronic concepts are increasingly replacing mechanical ones. Here are a few examples: Just a few years ago, electronics manufacturers were sending their components to the locking system manufacturer. In future, though, the increasing importance of immobiliser, radio remote control and keyless entry will cause the electronics developer to assume the leading role instead. Similar developments can be observed in connection with display instruments, air conditioning, window-closing systems, etc..

The shift is made even clearer if we think one stage further, to a possible switch from hydraulic systems such as brakes and steering, to X-by-wire systems.
Based on these facts, the intention was to examine how this development toward so-called mechatronic systems[169] is assessed by automobile manufacturers with regard to the future importance and weighting of mechanics and electronics suppliers.
As the results show (Table 7.3), electronics are clearly rated as being important (Questions A and B), although the responses make it clear that system suppliers must cover both fields, mechanics and electronics, equally effectively in the future (Question D). According to manufacturers, overall responsibility will not shift to electronics suppliers (Question C).
The clear statement that software know-how will take on a key role in the future forms another interesting aspect to emerge from the study.
What implications does this have for suppliers?

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[169] Mechatronic is an expression which encompasses the combination of mechanics and electronics. Regarding mechatronics, see Seipler, D.G./Zechnall, M., Electro-mechanical vehicle integration: Technological and structural implications for the automotive supplier, SAE paper 96C068, conference 1996, pp. 527-530; Duncan, C.I./Auzins, J., Electronics integration and architecture for cost savings and increased functionality, VDI-report, No. 1287, 1996, pp. 733-753; Thoma, P., Future Needs for Automotive Electronics, presentation paper, IEEE-1994, pp. 532-539

- A genuine system supplier requires a combination of mechanical and electronic know-how.
- Software function will play a key role in the future. Constantly rising requirements - comfort and conveniences, safety, quality and reliability, new regulations, vehicle performance, environmental standards, etc. - are producing a dramatic rise in the standards of software performance. This in turn is imposing greater demands on hardware performance (processor speed, memory space -RAM, ROM - CAN interface, etc.).
- Suppliers of pure mechanical systems only will face increasing competition in the field of sub-systems and components in particular.

	Yes	No	No statement
A) Although the content managed by electronics suppliers is constantly rising, the mechanics suppliers will still hold overall responsibility. The electronics suppliers are the sub-system supplier or component supplier (n=14).	1	9	4
B) The designer of the electronic (control unit) will asume more and more responsibility due to the rising importance of electronic hard- and software (n=14).	7	2	5
C) In the long run, the electronic designer will assume the entire responsibility (n=14).	4	4	6
D) A system supplier must have a knowledge of both mechanic and electronic (n=14).	12	1	1
E) A knowledge of software (system function etc.) will be the key issue in the future (n=14).	9	2	3

Table 7.3: Observations on the importance of mechanics/electronics

7.2 Supplier requirements with reference to the individual segments in the relevant fields.

A knowledge of what the end customer demands of a product is essential and can be acquired with the aid market research instruments. By the same token, it is equally important to know what the manufacturer of the end product requires of its suppliers in order for it to achieve its goals. As automobile manufacturers are currently experiencing a phase of re-orientation, with regard to production and development depth for example, it is particularly interesting for the companies dependent on the manufacturer to know what the manufacturers' future requirements will be.

This re-orientation is not just about marginal changes, but rather involves complete re-organisation of the supplier structure with classification into systems, sub-systems and components. Therefore, it would certainly be an advantage to have a knowledge of the individual segment requirements in particular in order to be able to adapt to new conditions in good time. As the information provided in the studies carried out by BOSSARD, WILDEMANN, FIETEN, SCHINDELE and GUTBERLET/HOHBERGER/SCHREINER[170] and in published interviews with those responsible at automobile manufacturers is

- formulated generally and not substantiated by figures,
- difficult to compare due to the different supplier segments and
- often only concerned with parts of the overall topic (focus on one segment, usually system suppliers),

the second main goal of this study was to provide an explorative analysis of

- what the most important requirements of automobile manufacturers are and how these are assessed and
- whether there are differences in the requirements for individual supplier segments and if so, how significant they are.

The results presented in Figures 7.3 and 7.5 show the arithmetical means of the points about which questions were asked. The ranking scale ranged from 1-6, with 1 being the lowest and 6 the highest ranking, and n referring to the number of responses.

7.2.1 Expectations with reference to both technical aspects and quality

The results presented in Figure 7.3 clearly show how the rankings of requirements differ, between the respective variables on the one hand and the supplier segments - system, sub-system, component suppliers - on the other.

[170] See Gutberlet, G./Hohberger, P./Schreiner, P., Kooperationen in der Kfz Zulieferindustrie, research report, 1995; Bossard Consult, Kooperationen und Partnerschaften zwischen Lieferanten der ersten und zweiten Zulieferebene, investigation report, Frankfurt, 1996; Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, 1993, pp. 36-44; Fieten, R., 1992, p. 93; Schindele, S., 1996, p. 111

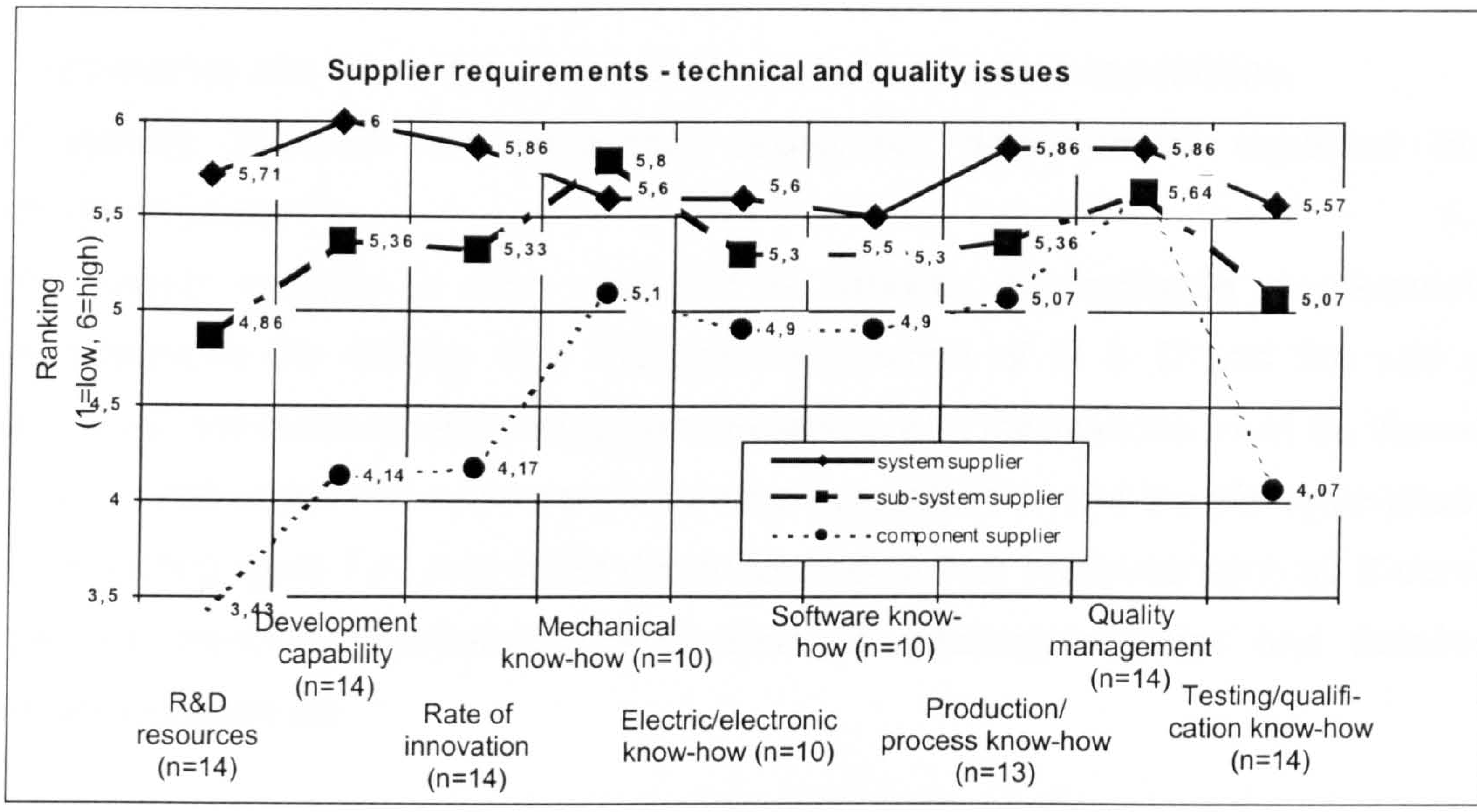

Figure 7.3: Supplier requirements from the OEMs` perspective
(the values are mean values)

Particularly the requirements concerning the more capital-intensive factors such as available R & D resources, development capabilities, which refer to the ability to work out solutions to problems independently, and the innovation rate reveal a major difference between system, sub-system and component suppliers. In cases where system suppliers are expected to produce good development results and pioneering achievements, components suppliers can concentrate on their specific, more restricted tasks with a lower budget. The points, “R & D resources” and “Innovation rate”, were ranked about 0.4 and 0.25 higher for the component supplier by the people who participated in the telephone interview - middle management.

This result was to be expected in view of increasing globalisation, which has put pressure on system suppliers to enter newly emerging markets jointly with automobile manufacturers, ever greater product complexity and intensified outsourcing. In the current environment, where companies are competing for international innovation leadership, a company's technology strategy forms an essential part of the corporate strategy, which is also gaining in importance. Research and development, the root of development capability and innovation rate, form the basis for the operative structuring of technology strategy. System suppliers (direct suppliers) in particular are required to help automobile manufacturers achieve their objectives, i.e.

- defending and expanding current business,

- taking advantage of new business opportunities and
- increasing and intensifying the company's technological capabilities,

by making available the necessary resources, development expertise and innovation power[171].

The system supplier is also expected to smooth out possible development bottlenecks at the OEMs. The strategic importance of R & D and the use of resources, the build-up of development expertise and innovations must be viewed in the overall context of a company's strategic possibilities and the life-cycle phase of products (Figure 7.4) and made dependent on further analyses such as S-curve analyses, trend extrapolations, observation of risks/opportunities and detailed market analyses etc[172].

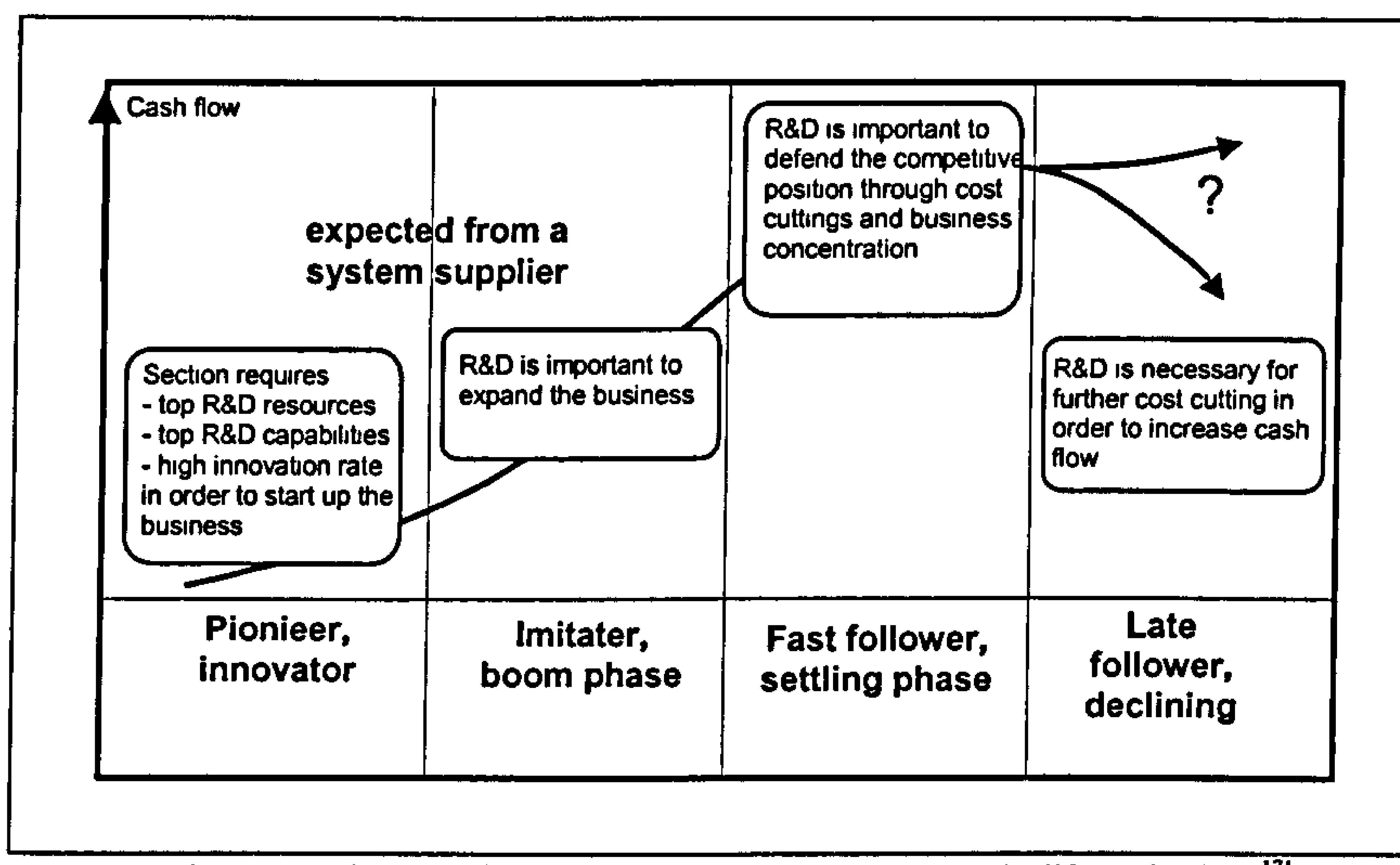

Figure 7.4: The strategic importance of R&D depending on the life-cycle phase[171]

The blocks of fixed costs passed on to the system supplier by the manufacturer, e.g. for R & D activities and production capacities constitutes a risk. The supplier must provide and finance (in advance) a considerable number of these without receiving the necessary assurance from the manufacturer that the services provided can also be applied in practice. Financing of the services which the system supplier is required to provide thus forms part of the business risk.

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[171] See Saad, K.M./Roussel, P.A./ Tiby, C., Management der F&E-Strategie, 1993, p. 32; Henkel, C.B., Akquisition und Kooperation als strategische Alternative aus Sicht der deutschen Automobilindustrie, 1992, p. 74

[172] See Twiss, C.B., Managing Technological Innovation, 1993; Wolfram, B., Strategisches Technologiemanagement, 1991; Holst, J., Lean Development, 1995, pp. 89-115; Eversheim, W./Böhlke, U.H./ Martini, C.J./ Schmitz, W.J., Wie innovativ sind Unternehmen heute, in: Technische Rundschau, No. 46, 1992, pp. 100-105; Kümmerle, W., Building effective R&D capabilities abroad, in: Harvard Business Review, March - April 1997, pp. 61-70

When deciding whether to develop, e.g. from sub-system supplier to system supplier, the different requirement levels are a good indication of the number of adjustments that will have to be made, depending on the respective starting basis. The differences in the other areas, mechanical know-how, know-how in software, electric/electronics and production, are less apparent. Since these areas already demand high standards of the component supplier, a forward strategy in the suppliers' pyramid would be less problematic.

The comparable requirement levels for the mechanical, software and electric/electronics fields is also made clear. This serves to confirm the automobile manufacturers' statements described in the previous section (Point 7.1.4).

It is also interesting to note the importance of quality management. The high ranking for component suppliers can be explained by the fact that the quality of the system as a whole can only be as good as the quality of the poorest single component.

The quality aspect has gained significantly in importance in recent years. This can be attributed to two main reasons:

- If we look at the pattern of modification costs throughout the development process in the areas of preventive and traditional quality management, the use of quality management is evident in all segments. The situation will be further pressured by increasing complexity[173].
- The quality aspect is becoming an increasingly important competitive factor.

This is not only reflected in the zero error strategy[174] systematically pursued by manufacturers, but can also be seen in the large number of methods developed within Quality Function Deployment[175].

The requirements for component suppliers with regard to testing and qualification know-how are much less stringent, which can be attributed to lower product complexity.

7.2.2 Expectations with reference to logistics, service and economic factors

The relevant factors in respect of logistics, service and economics are presented (Figure 7.5) in the same form as the demands in respect of technology and quality were investigated, analysed and presented. Here, once again, we find a marked

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[173] See Curtius, B., Quality Function Deployment in der westdeutschen Automobil- und Zulieferindustrie, PhD thesis, 1996, p. 81

[174] See Kreft, W. (Interview), Die Anforderungen werden steigen, in: Automobil Produktion, Feb. 1996, pp. 70-71

reduction in the level of demands from the system supplier down to the sub-system supplier and further on down to the component supplier.

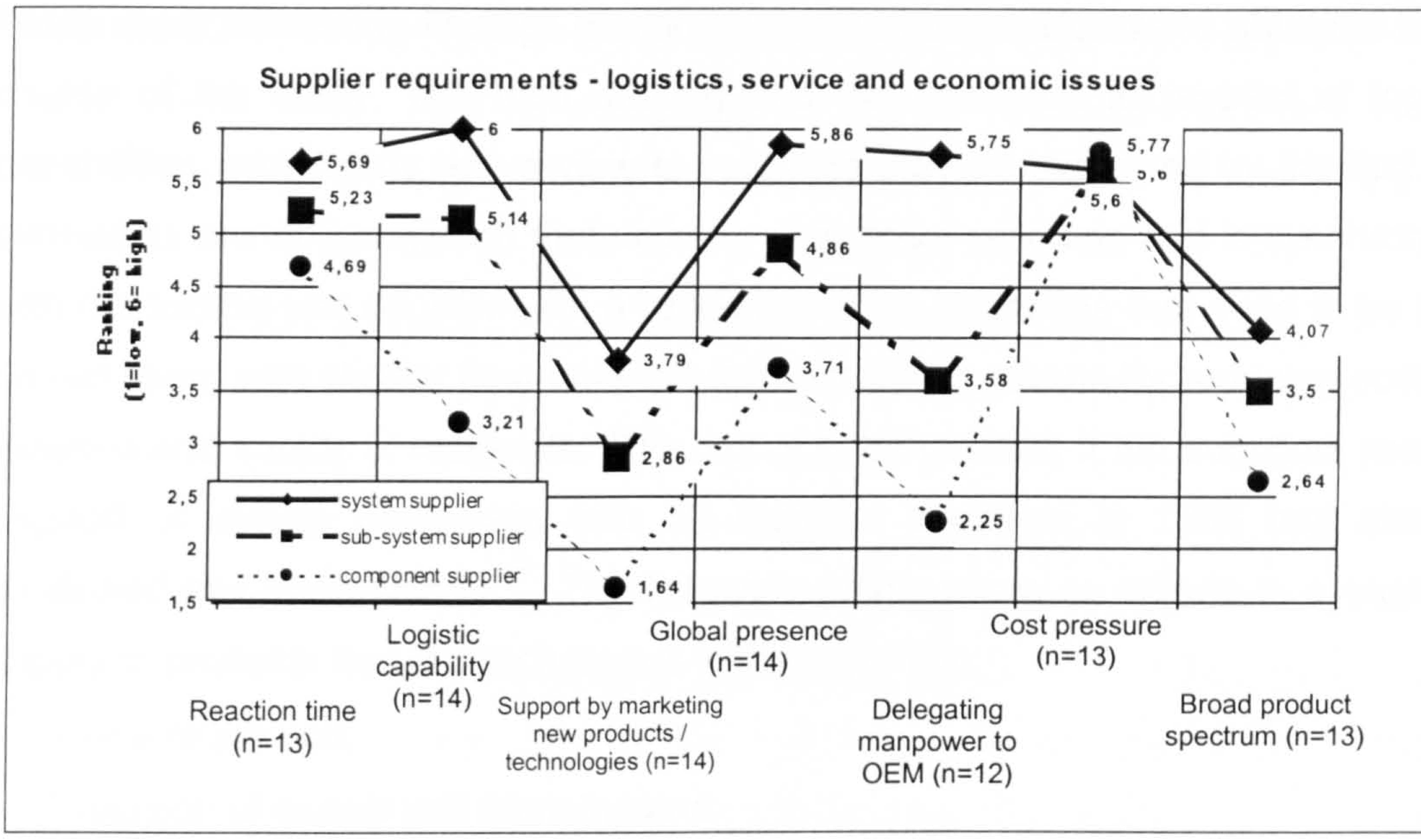

Figure 7.5: Supplier requirements from the OEMs` perspective
(values are mean values)

As already observed in connection with technology and quality, system suppliers must come to grips with a very high level of demands and expectations.

According to the results, carmakers in all three segments do not demand any significant support from their suppliers when it comes to marketing new products or technologies and a broad range of products. The fact that having a broad range of products did not rank high on their list of priorities is in agreement with the information derived from the interviews. According to the responses from the respective persons in charge and the decision-makers, carmakers do not aim to procure everything from one source. Moreover, it is much more important for a supplier to delimit its product portfolio and to fully satisfy the requirements connected with it in every respect, or to extend the product portfolio carefully if synergy effects or technical overlap make such action advisable or necessary, as applicable. The research results obtained did not support the theory that vehicle interiors would primarily be out-sourced as a complete unit only in the foreseeable future as described in the literature[176]. This finding may be viewed as further

[175] Relevant methods and instruments regarding the quality management: ISO900x, VDA guideline, house of quality, Malcolm bridge award, QFD based on Kao or Taguchi
[176] See Karsten, H./Vaessen, W., Der Innenraum als System, in: Automobil Produktion, August 1995, pp. 54-56

evidence supporting the assumption that suppliers must not obtain too much power.

Three more interesting findings meriting a detailed discussion were obtained in the course of the study. The high ranking and the demands in respect of logistic capabilities, particularly with a view to suppliers may be explained by the fact that carmakers are of the opinion that delivery of supplier products that is synchronous with production and coupled with a reduction in the quantities that need to be held on call along with shorter time intervals forms the best means for reducing costs of logistics and supply of materials. This can only be realised if the suppliers receive support. A survey conducted with 50 German suppliers in 1989 has already confirmed this trend clearly[177]. The following points serve as criteria in evaluating supply of products that is synchronous with production:

- Value of the unit,
- Precision of supply unit planning and
- Additional geometric characteristics (volume, bulkiness, etc.).

Entry of these parameters in a matrix allows evaluation of the suitability of delivery that is synchronous with production (just-in-time, JIT[178] delivery)[179]. Beyond that, the time of assembly and the number of the variants that need to be dealt with are also relevant for JIT-procurement.

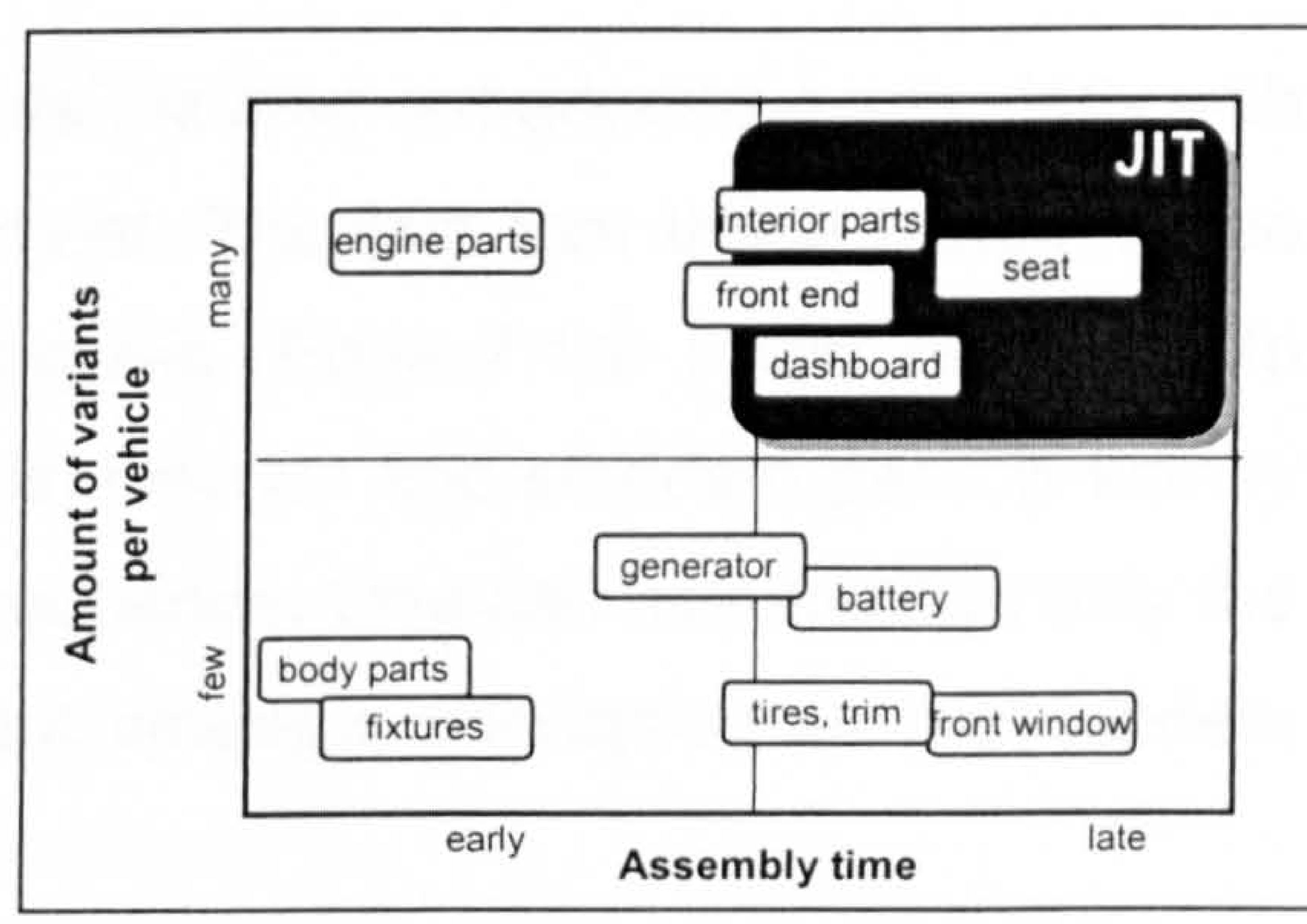

Figure 7.6: Example of JIT delivery (source: Sauer K., 1990[179])

This leads to the result shown in Figure 7.6 The units shown in the upper right-hand field are suited for JIT delivery.

The fact that precisely this field is covered by system suppliers makes it easy to understand that carmakers are very demanding here due to the fact that the potential for reducing costs is very significant.

177 See Fieten, R., Erfolg bedarf der Strategie, 1989, pp. 38-44

178 The expression JIT supply is not defined precisely in the literature and actual practice. Therefore, automobile manufacturers use this expression with different meanings. For instance: BMW understands JIT to be one delivery per day as a minimum with a max. storage of 2.5 days production volume; at VW and Daimler Benz (now DaimlerChrysler), JIT means frequent delivery with no storage.

179 See Wildemann, H., Produktionssynchrone Beschaffung, Handbuch für die Einführung einer JIT-Belieferung, 1987; Sauer, K., International supplier relationship of the German car manufacturer, PhD thesis, FIM Research Institute for International Management, St. Gallen, Switzerland, 1990

A rather wide gap has emerged between system suppliers and sub-system suppliers in connection with the point, “delegating manpower” to the OEMs. The reasons for this circumstance are twofold. There is the intention on the one hand of manufacturers to involve the system suppliers much sooner in the development process so as to even be in a position to deal with ever shorter development periods. This point is dealt with more specifically under point 7.3. On the other hand the highly complex tasks make it necessary for manufacturers and suppliers to work together closely. This can be achieved by using so-called resident engineers among other things. If we compare this point with the requirements in respect of R & D resources and rate of innovation, we can ascertain excellent agreement of the results. As an additional input at this point, the middle management people at the related OEMs who took part in the telephone interview ranked the issue, “delegating manpower to the OEMs” 0.3 higher for the sub-system supplier and 0.8 higher for the component supplier (expecting a higher level of support from those levels). They ranked the issue, “broad product spectrum” 0.3 - 0.6 lower for all levels.

Evaluation of the point, “pressure from costs”, is also remarkable, particularly with reference to the component supplier segment. The fact that these results agree with the statements discussed in the foregoing (Point 7.1.2) with reference to primary reduction of costs in connection with location and standard parts is worthy of mention. Fiercer competition is the consequence. One can assume that only the companies who are best able to implement strategic orientation as cost leaders will be able to survive in this segment.

A different unit of evaluation was selected for the following two factors (Figures 5.7 and 5.8) in order to achieve better representation and facilitate comprehension. The respective units correspond to the ordinate division used in the graphs. Both graphs are particularly interesting in that they provide a good cross-comparison of the demands placed on suppliers that have been studied (sections 7.1.4 and 7.1.5) and of the general conditions characterising future joint work (Chapter Eight). The statements concerning the level of potential

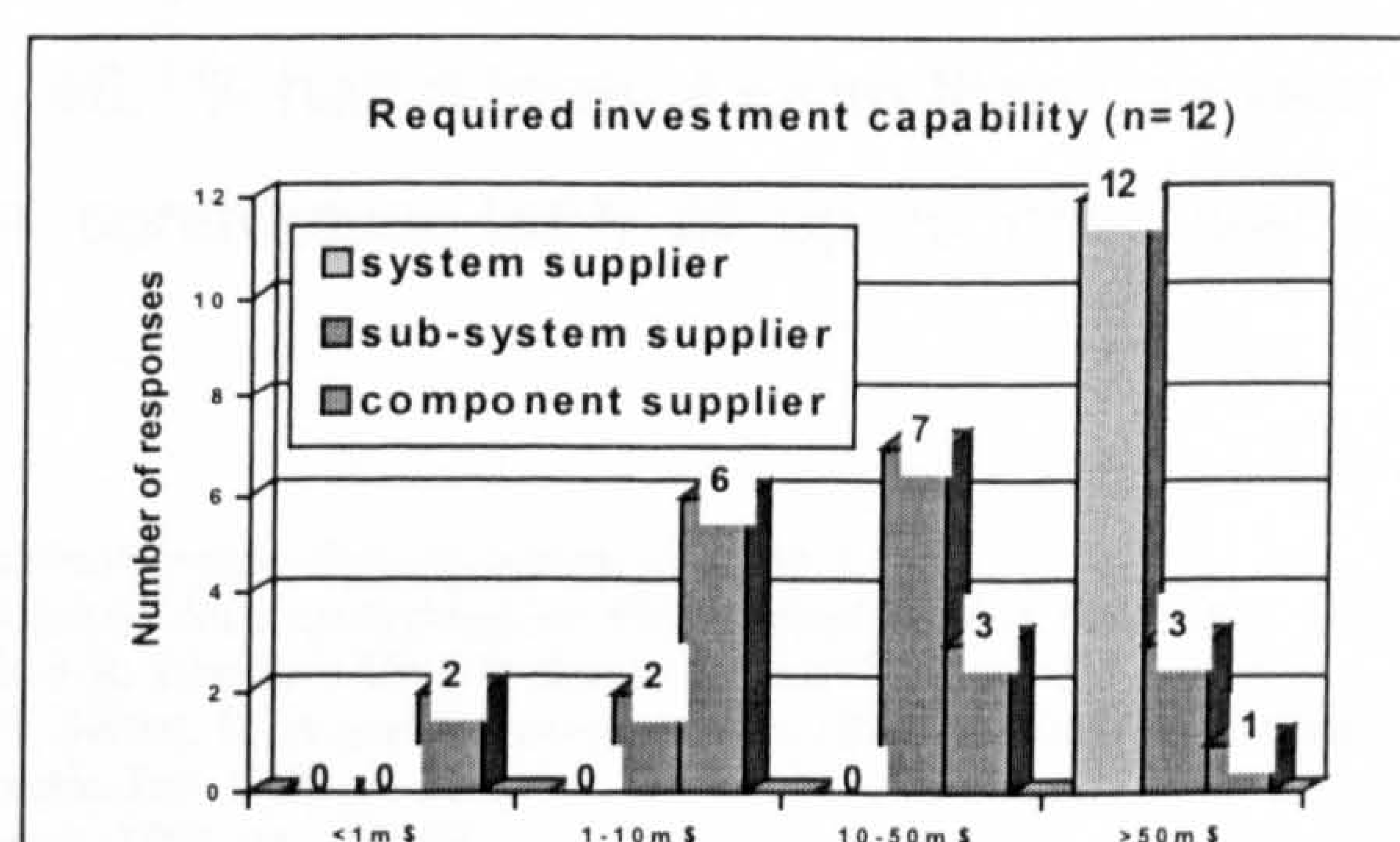

Figure 7.7: Level of investment

investment capabilities (Figure 7.7) correlate very well with the demand profiles. The values given do not refer to a particular process, but rather are intended to serve as a point of reference and a basis for comparing the supplier segments for investments in development with respect to facilities/production sites. When one considers the development budget for system units e.g. CVT (Continuous Variable Transmission) or dashboards, sums of around $20-30 million are a realistic investment volume, one that must be pre-financed by suppliers in part. A similar situation applies when system suppliers are forced to follow their respective manufacturer when it moves to a new production site within the country or abroad. Just to name a few examples, Lear, Magna Eybl, Grammer, Seeber etc. have set up new production sites in the BMW sub-supplier park in Wackersdorf[180], and Ecia has relocated its production of front-ends directly to inside the Audi plant[181] so as to be in a position to supply the manufacturer in accordance with its needs and with the required flexibility. Suppliers have followed Daimler-Benz to Brazil in order to manufacture parts for the A-Class. ZF set up a new plant for axle units near Daimler-Benz's (now DaimlerChrysler) production site in the USA.

Long-term affiliations with customers are needed in order to be able to affect the high investments for development and transactions and to provide the supplier with the security it needs to adjust capacity and productivity accordingly. When taking the significant demands placed on system suppliers and the performance expected from them into account, decisions on the part of the companies that involve significant amounts of capital respectively development activities and expansion of production can only be taken in a manner that is viable economically if they are based on life-time contracts. According to the experts[182], future competitive strength can only be assured if the joint work of manufacturers and suppliers is intensive and marked by partnership and trust.

Whereas WILDEMANN's[183] empirical investigation found that 13.2% of contracts were based on the life-time of production, 46.1% had a term of more than one year and 28.9% of those surveyed stated a contractual term of up to one year -

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[180] See Automobil Produktion, Oct. 1997, p. 10

[181] See Meyer, M., The module supplier on the factory area of the automobile manufacturer, report, 1996, pp. 1-17

[182] See Zirger, B.J./Maidique, M.A., A model of new product development: An empirical test, in: Management Science, No. 7, July 1990, p 867-88; Hartley, J.L/Meredith, J.R/McCutcheon, D./Kamath, R.R, Supplier's Contribution to Product Development: An Exploratory Study, in: Engineering Management, Vol. 44, Aug. 1997; Seifert, H., A question of integration, 1994; Backhaus, K./Weiber, R./ Droege, P.J, Innovationsdruck für Zulieferer, in: Automobil Industrie, Jan. 1993, pp. 32-33

[183] See Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, 1993, pp. 153-154

although it should be noted that no distinction was made between the individual supplier segments and that the persons surveyed were suppliers,

- according to the investigation at hand (Figure 7.8) approx. 50% of those surveyed stated they had a life-time contract as the basis for joint work.

The figure for those working in the system supplier field in particular was more than 90%. According to EDDY GEYSEN, former Vice-President responsible for Procurement at General Motors Europe, in the course of all of the structural changes in the suppliers' sector, approx. 80% of purchasing volume will be governed by long-term contracts by the year 2000 and approx. 50% of these will be life-time contracts[184].

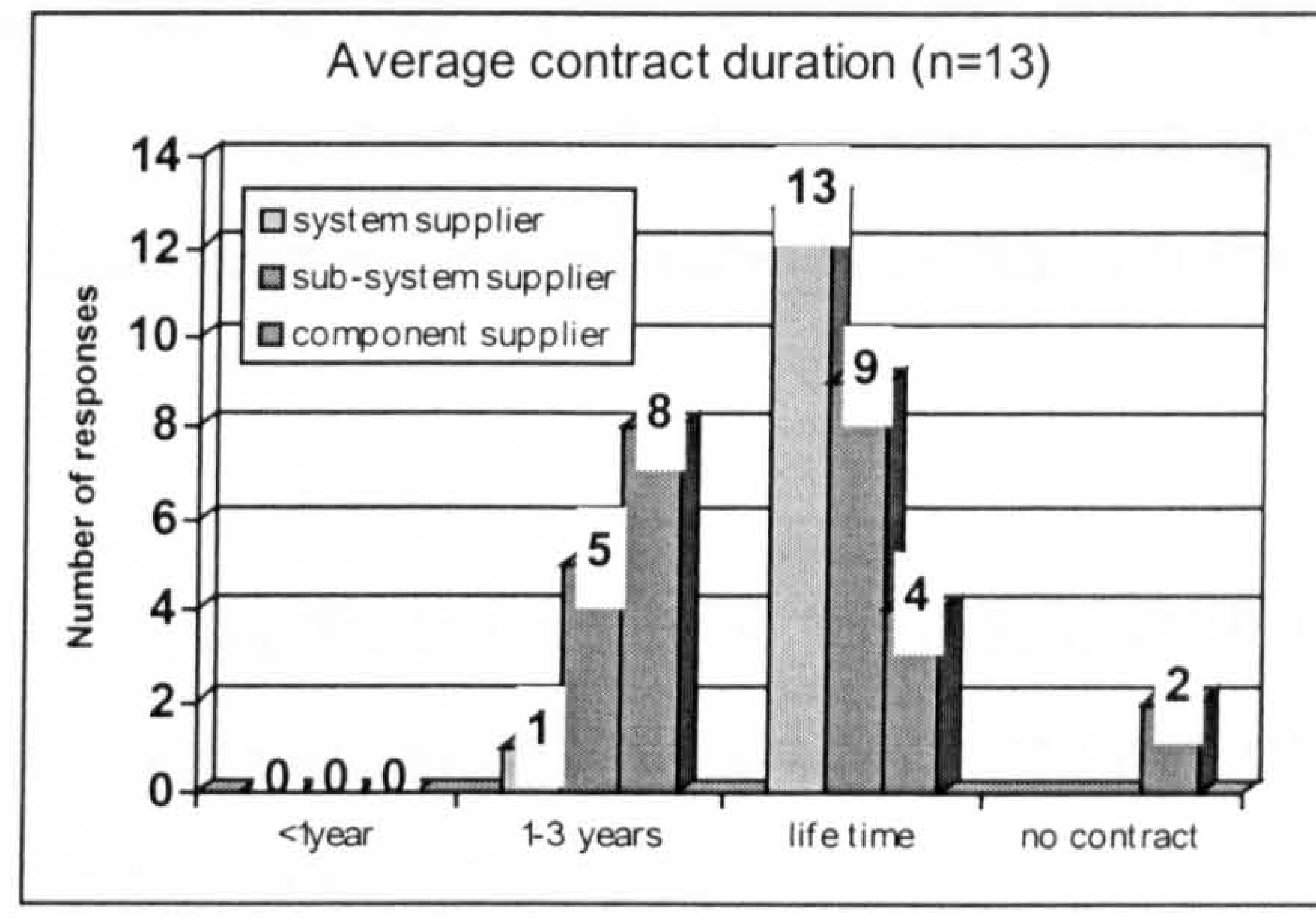


Figure 7.8: Average contract duration

7.3 Critical aspects and the advantages of closer co-operation.

As already mentioned, more intensive joint work, which also implies earlier integration of the supplier in the development process, will be accorded more importance in the future. According to GERRIT HUY, former director of Daimler-Benz's (now DaimlerChrysler) pre-development[185]:

"Partnerships that function well both internally and externally form the key to companies' future success. Partnerships, particularly with suppliers, are an essential for mastering structural change...".

She goes on to explain how the pressure from suffering as a result of structural change that is long over-due is utilised jointly in order to effect the necessary internal and external changes needed to shape more efficient partnerships.

It makes no sense for an automobile manufacturer to plan its costs if the supplier continuously comes along with unplanned cost increases. Beyond that, it does not do any good to optimise and shorten internal development processes if the

[184] Geysen, E. (Interview), Der Bedarf wird jetzt weltweit koordiniert, in: Automobil Produktion, Feb. 1996, p. 29
[185] See Huy, G., Strukturwandel in der Automobilentwicklung, report, 1992, p. 21

processes at the suppliers' are merely adjusted moderately in parallel. All of this raises the question as to how well a development partnership can function if only one party's interests dominate, namely those of the OEM.

EDDY GEYSEN stated as well, that it is more important than ever before to elaborate the parameters for intensive, successful joint work based on trust. He points to more intensive dialogue with the suppliers and emphasises the exchange of information on plans and goals on the one hand and suppliers' priorities on the other hand.

This was one point that RICH presented as a significant point of emphasis in the European automobile industry in his study investigating the implementation of Japanese supplier management practice in the United Kingdom.

"Indeed, the assemblers in the West, have not been active in developing interfaces to capture the full advantages of partnership sourcing, preferring instead, to demand products to drawings with the added ritualistic annual price negotiation of stick waving."[186]

FUJIMOTO presented three possible alternatives for external integration in his detailed work on the *"Organisation for effective product development"*:

- *"Setting up separate organisational sub-units which specialise in external integration;*
- *Assigning the role of external integration to the existing functional units;*
- *Assigning the role of external integration to internal (cross-functional) integration";*

and clearly points out the significance of external integration in addition to internal integration and functional specialisation for improving system integration and increasing competitive strength[187].

[186] See Rich, N., Kaizan: The application of performance benchmarking for a customer-focussed supplier association, Cardiff Business School, UK, conference paper, 1995, p. 9

[187] Fujimoto, T., Organisation for effective product development: The case of the global automobile industry, PhD thesis, Harvard Business School, 1989, p.125

WILSON and GEMINI also take up this concept of supplier integration and refer to the time-dependent displacement of integration and integration at the various supplier levels in their elaboration. Whereas the system supplier is integrated at the beginning of the production planning and development phases, the component supplier is not integrated until the end (Figure 7.9). This already shows clearly how significant the leverage and potential influence are that component suppliers can exert on the system suppliers[188]. Beyond that, they perform important tasks for the manufacturer and the supplier in the course of the respective project.

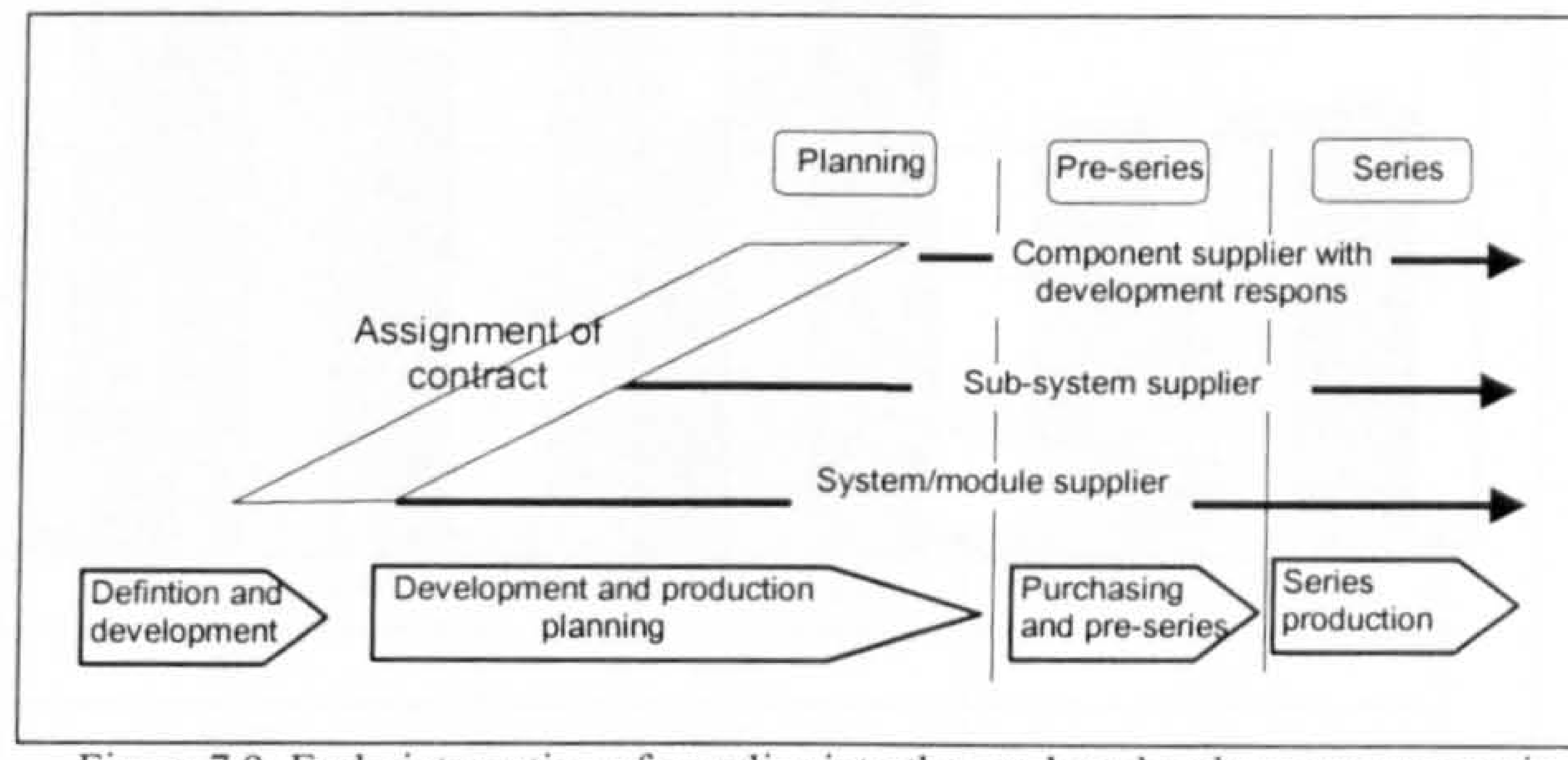


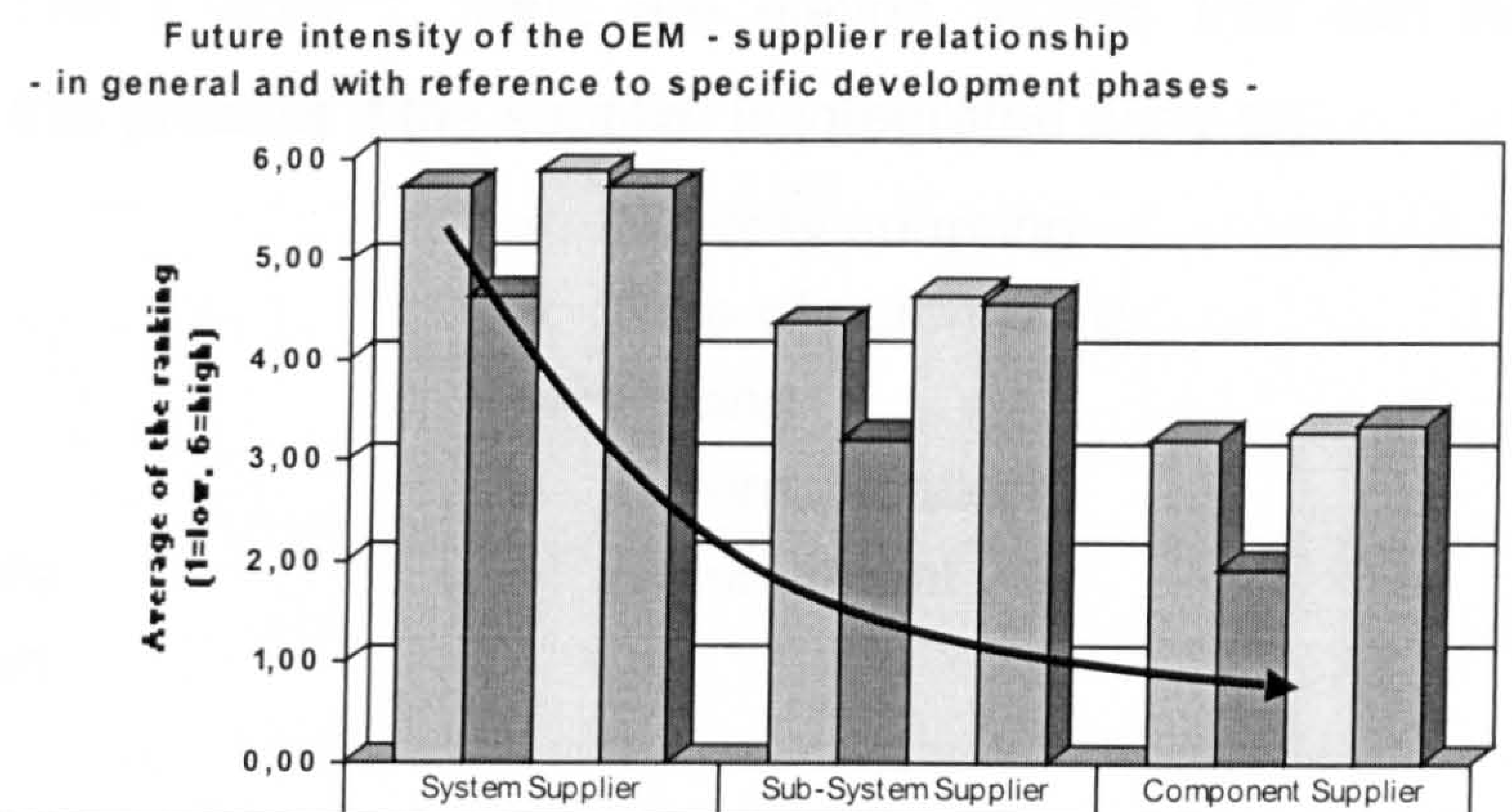
Figure 7.9: Early integration of supplier into the product development process in the automobile industry requires new roles (source: Wilson, Gemini, 1997[188])

However, as already mentioned in the demands listed in the foregoing (Section 7.2), the relevant literature does no more than offer general, descriptive statements without providing any numeric underpinning or comparisons of the supplier segments regarding the intensity of integration of suppliers in general or specifically. Accordingly, this part of the study seeks to stop this gap. As in the research results presented in the foregoing, these results also represent the arithmetic mean value of the efforts made by carmakers with 1 being the lowest and 6 being the highest possible ranking and "n" representing the number of mentions.

The following four points relating to the analysis of the research results (see Figure 7.10) merit special attention:

- The generally high ranking given the future situation in respect of the relationship between OEMs and suppliers, which gives grounds for assuming that the current situation will improve.
- The relatively high ranking given sub-system suppliers and component suppliers. This result is in fact very high when considering a course of development where a concept of system suppliers according to which only a few suppliers have direct contact with the manufacturer and also co-ordinate the sub-suppliers is implemented consistently.

[188] See Wilson, C./Gemini, C., Lean design in the automotive supply chain through integration, conference paper, 30th Isata, 1997, p. 218



	System Supplier	Sub-System Supplier	Component Supplier
General relationship intensity (n=14)	5,71	4,36	3,21
Product planning phase (n=14)	4,64	3,21	1,93
Product development phase (n=14)	5,86	4,64	3,29
Qualification/application/testing (n=14)	5,71	4,57	3,36

Figure 7.10: Future intensity of the OEM-supplier relationship
a) in general and b) with reference to specific development phases

- The continued reserved attitude relating to the integration of suppliers into the product planning phase. It is precisely this phase that trend-setting decisions relating to concepts, quality, production safety, costs, etc. are made in.
- Referring to the general statement in Section 6.1.1, the ranking of future supplier relationship intensity from the telephone interviews (participants from middle management) was higher compared to the standardised questionnaire outcomes (participants from the senior management level).

The following differences analysed in detail:

	System supplier	Sub-system supplier	Component supplier
General relationship intensity	+ 0.08	+ 0.5	+ 0.6
Product planning phase	+ 0.3	+ 0.6	+ 1.0
Product development phase	+ 0.05	+ 0.4	+ 0.6
Qualification/application/testing	+ 0.08	+ 0.5	+ 0.8

As already discussed in Section 4.3, every alliance and acquisition is associated with risk-taking. At the same time, however, a situation marked by more intensive collaboration with suppliers can also provide suppliers with the opportunity to improve their own position and to reduce the likelihood of risks that might have a negative influence on their competitive strength.

According to M. PETER's work[189], there are eleven factors that can have a decisive influence on this process if the supplier is integrated early on.

- Standardisation
- Design freeze
- Supplier selection
- Supplier source
- Number of suppliers
- Supplier localisation
- Minority sourcing
- Role of purchasing
- Pricing
- Communication
- Commitment

He does not, though, deal with the effects of early integration of the supplier in his study.

The subject of supplier integration is gaining in importance. It was developed further as an off-shoot of the Simultaneous Engineering Method and developed further using structures resembling those of a project house where suppliers send members of their staff directly to the manufacturer's for a specified period of time. The fact that future development can only be mastered by collaboration that is intensive and innovative, transcends fields of responsibility and competence and is marked by an atmosphere of partnership makes this all the more important.

L. BECKER (Purchasing Manager at BMW) stated that costs could be reduced by 20%, due to the fact there is still too much redundant work and follow-up work taking place that can only be dispensed with by integrating the suppliers into the development process earlier on. The purchasing manager at Ford even goes further, stating that a savings potential of 40% could be achieved by improving co-operation between the manufacturer and the supplier[190].

A study performed at the UNIVERSITY OF AUGSBURG and concentrating on an investigation of partnership and the transfer of knowledge arrived at the sobering conclusion that actual practice is characterised by precisely the opposite of partnership, trust and the exchanging of information and that this behaviour tended to impede suppliers' innovation activities[191].

[189] See Peter, M., Early supplier involvement (ESI) in Product Development, PhD thesis, University of St. Gallen, 1996, p. 111
[190] See article, Zulieferer-Zukunft, in: Automobil Produktion, special edition, 1993

In the course of the study, carmakers were surveyed on the points listed in Figure 7.11 with the aim of better categorising and evaluating the subject at hand, namely that of earlier and more intensive integration of suppliers, using the current situation as a point of departure.

If we now compare the points that tend to have a favourable influence on business with those exhibiting unfavourable tendencies, we see clearly, although granted not as clearly as expected, that carmakers tend to view earlier integration of suppliers rather favourably.

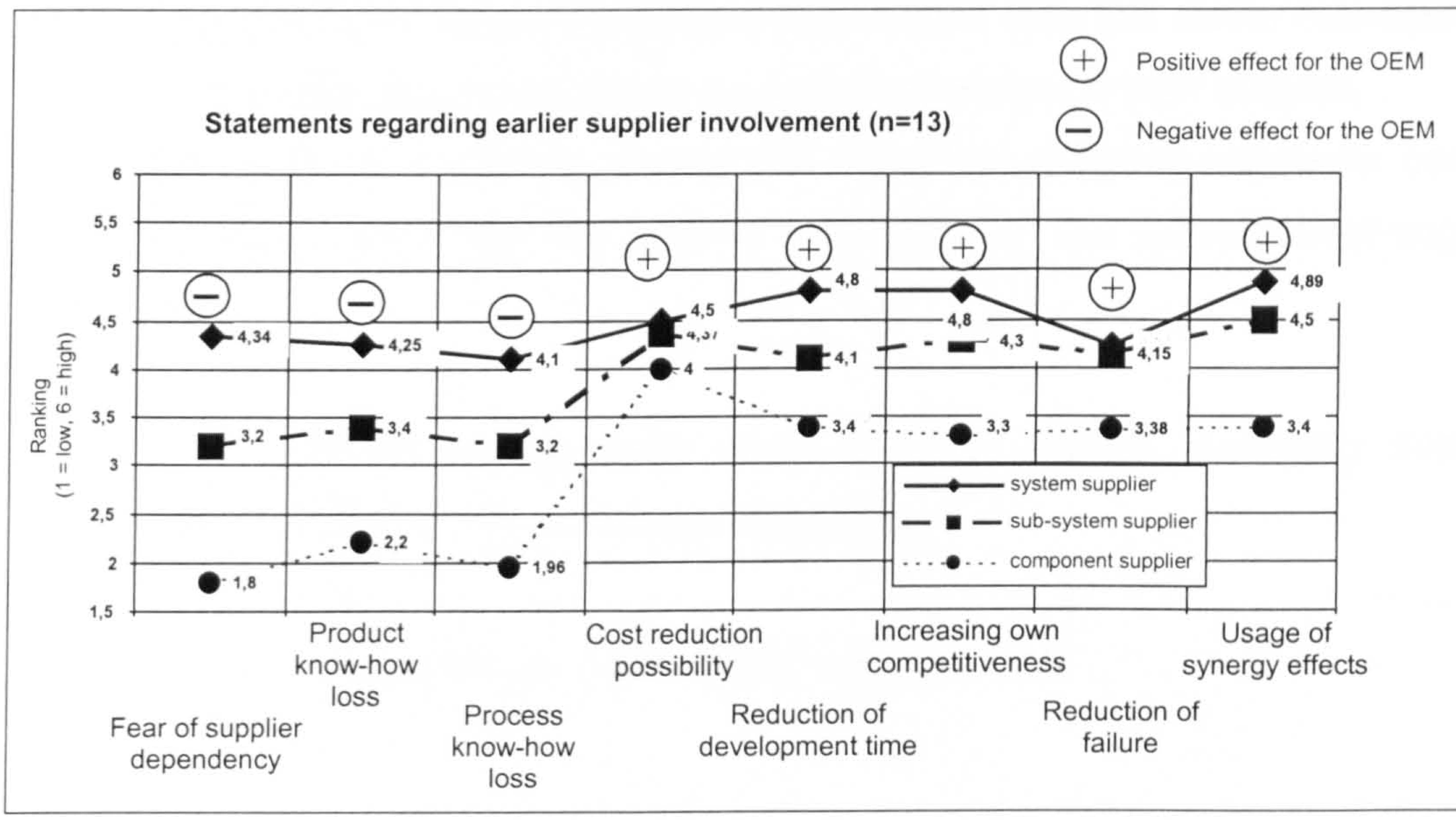


Figure 7.11: Some observations on earlier supplier involvement (values are mean values)

Beyond that, they tend to express this view in their evaluation of the points helping them secure or develop competitive strength.

As regards manufacturers, co-ordinating with suppliers and making use of existing development work and results contributes significantly to reducing the time required for development, improving competitive strength, utilising synergies and to further improving the cost structure. A remarkable aspect about the latter point is that effects with a similar high ranking can be expected on the part of the component suppliers, even though they are not integrated into the development process until later on.

[191] See Peters, J., The customer as a check for innovations, in: Automobil Produktion, Mai 1996, pp. 10-11

Despite these tendencies, there is marked scepticism toward allowing know-how of products and processes to be relegated to the suppliers with the ensuing risk of increasing dependency. This view represents a counter-pole to the trend-setting and necessary steps toward integration that should not be underestimated.
The information from the - non-representative - telephone interviews (please see Section 6.1.1) was quite interesting. The average ranking of fear of dependency, product/production know-how loss was 0.2 to 0.35 for sub-system and component suppliers and lower for the system supplier at 0.4 to 0.5. This may be due to the fact that these persons work together with the suppliers more closely to the effect that they have more detailed operational information than the senior management level, and that this circumstance has a positive influence on their attitude.
The wide range of scattering among the individual supplier segments can be explained by merely citing the varying intensities of the manufacturer-supplier relationship.

Although the results do generally show a trend toward improving supplier integration, they do not yield a concise statement.

Al the factors investigated are summarised in Figure 7.12.

7.4 Summary

- Adjusting of the regular suppliers will continue. Reduction to 1/3 of the current volume.

- Manufacturers expect the reduction to yield the following average improvement rates:

20%	"cost reduction"
20-40%	"time-to-market will improve"
40-60%	"reduction of co-ordination efforts"
40%	"reaction time to market requirements"
40%	"innovation rate"
20-40%	"quality improvements"

- System suppliers must possess detailed and comprehensive product-specific know-how. Having a mere specialised knowledge of production that can be used as a basis for joining sub-systems or, as applicable, components that were purchased cost efficiently to produce systems and for delivering them to the OEM in accordance with its needs was rated as being insufficient.

- Electronics are becoming increasingly important. According to the manufacturers' statements, electronics suppliers will increasingly take over responsibility for entire systems.

- The view that system suppliers must dispose of know-how in both fields – mechanics and electronics – for future tasks was expressed clearly.

- Know-how in the field of software functions represents a core competency for the future. The software complexity and volume drives the hardware requirements concerning processor speed, memory space, interfaces like CAN, etc..

- The requirements for the segment system supplier in terms of engineering and quality were rated as being very high throughout (arithmetic mean value>5.5) on a scale of 1=low to 6=high.

- The demands placed on the system supplier are quite distinct from those applying to the sub-system supplier and the component supplier, particularly with reference to R & D resources, development capabilities and the rate of innovation. The situation is quite different when it comes to quality management where both had identical rankings.

- Logistics assume an important role (arithmetic mean value of the analysis = 6). Logistic concepts demonstrating cost-saving effects gain importance for the OEMs in the course of procurement of larger units (volume, weight) requiring capital-intensive transport and storage.

- The factor, "pressure from costs" was rated equally high for all supplier segments. This is a particularly important indicator for component suppliers and sub-system suppliers. Costs will be the primary decisive factor in terms of competition in this segment.

- Great importance will be attached to the intensifying of the manufacturer-supplier relationship and earlier integration in the development process. Companies will aim at implementing this concept in actual practice. However, the risk of supplier dependency, particularly on the part of system suppliers, the danger of having know-how move to outside the company are viewed as being significant.

A comprehensive presentation of the results of the investigations of the demands applying to the individual supplier segments is to be found in the following. This qualitative overview provides a clear picture of the varying profiles and rates of importance for the individual factors once more.

It can be used to derive important impulses for orienting business units in terms of structure, resources and strategy.

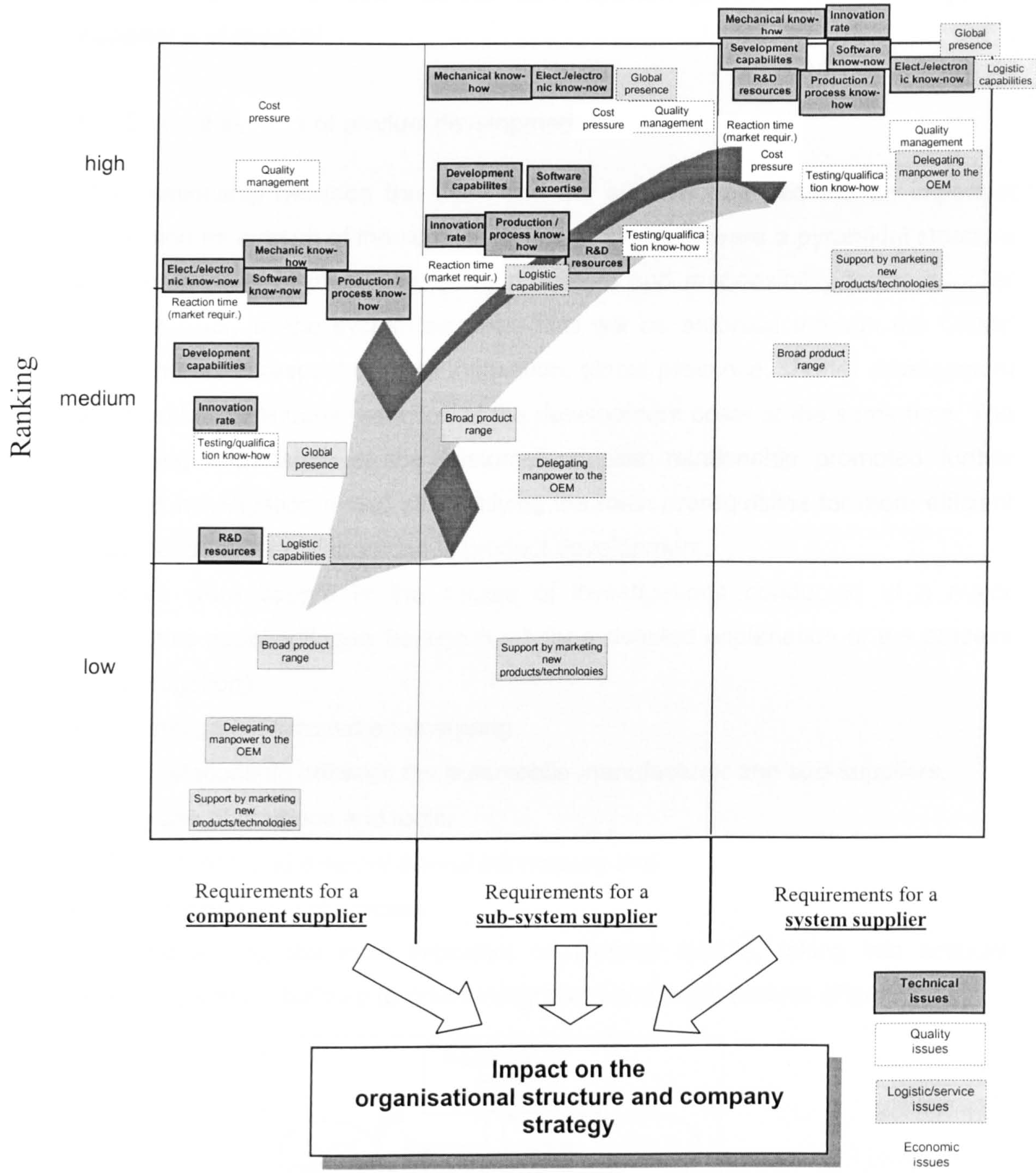


Figure 7.12: Summary of the supplier requirements of the individual supplier levels

Chapter Eight: The main prerequisites for a more efficient OEM - supplier relationship with a focus on the development process from the system supplier's viewpoint

8.1 General aspects of product development

The relationship between the OEM and the supplier has become an important dimension as a result of the supplier structure's trend toward a pyramidal structure and the transfer of more development content and responsibility to the supplier and especially to the system supplier. This will be enforced through the OEMs' requirements in respect of more innovation, global presence, shorter development times and a continuous reduction of the development costs at the same time. The increasing importance of the customer–supplier relationship prompted further detailed investigation aimed at identifying the main prerequisites for more efficient customer-supplier collaboration in product development.

Answers were sought in the course of investigations conducted at a major automotive supplier[59] (see Section 8.3.1 for a detailed explanation of the process of investigation).

The investigation focused on analysing:

- The relationship between the automobile manufacturer and sub-suppliers,
- The use of methods and tools,
- The internal and external flow of information and
- The general project process

and emphasising the most important competition factors, taking into account increasing system building (product integration) and requirements (Figure 8.1).

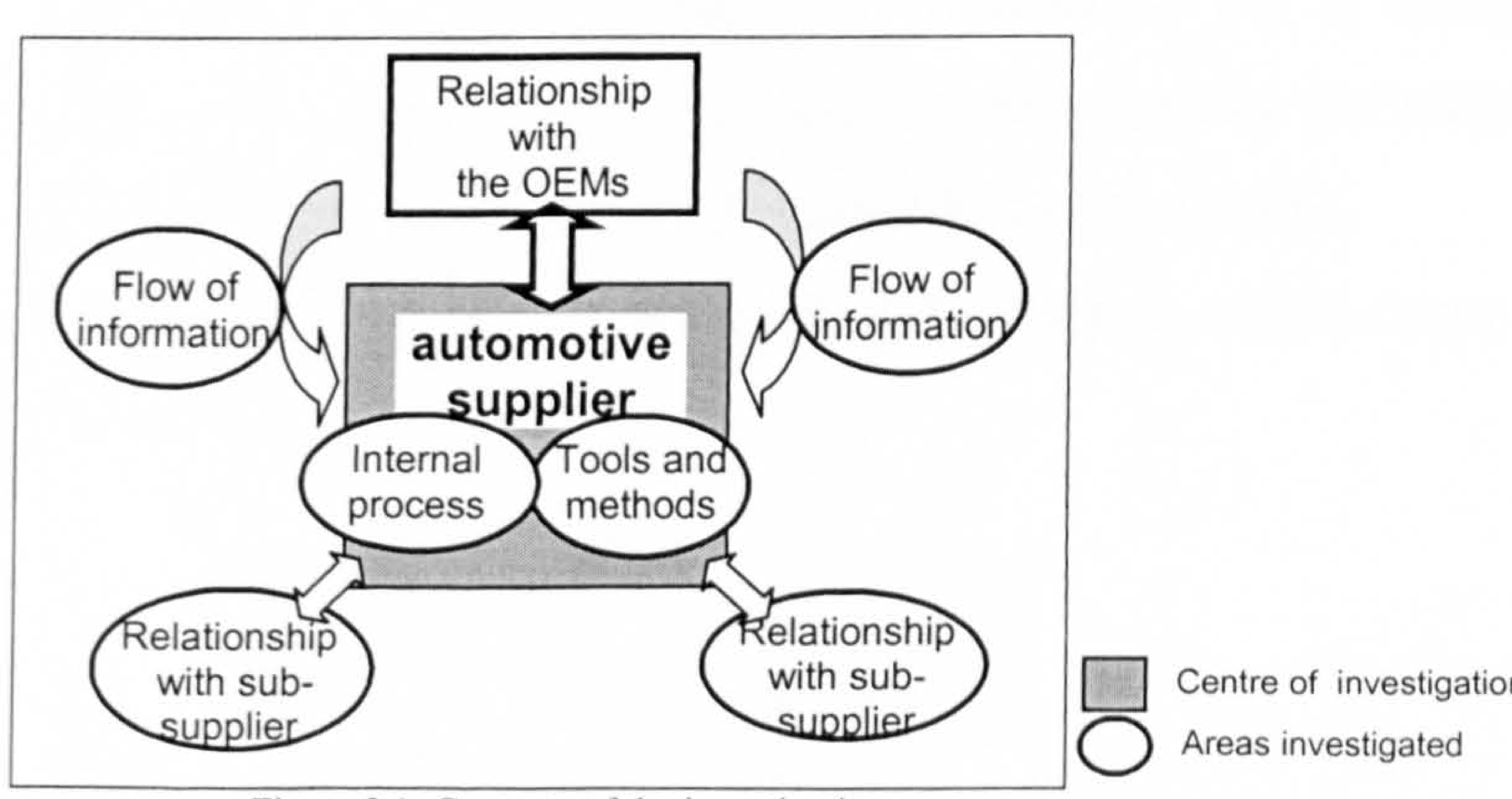


Figure 8.1: Contents of the investigation

Since the results of investigations are based on the statements of just one automotive supplier, the volume of data collected can generally not be considered representative. The reasons for limiting the investigation to just one supplier were:

- The time frame for conducting the investigation and analysing the data set a natural boundary.
- Other companies had probably refused their participation on account of the very comprehensive and detailed questionnaire. Due to the fact that the author was an employee of the company where the investigation was being carried out, it was now problem to obtain access to the persons participating (=project leader) in the study and, accordingly, to the information required.
- Due to the comparable organisational structures[192] and processes of major supplier companies described, the information obtained pointed out competition factors of future importance that can be applied quite readily to other companies and compared with their peripheral conditions. A review of the material published on the companies' organisational structure and the processes described for Bosch, Delphi, Visteon, Pierburg, Valeo Germany and Rockwell indicated similarities in these issues[193]. Therefore, it is quite reasonable to apply the results obtained from the investigation.

8.2 The product development process

8.2.1 Stages of product development

The terms, research and development *(R & D)*, product development, design and development are sometimes used as synonyms in literature and colloquial speech, and often have different or even contradictory meanings. As a basis for the following explanations, this chapter therefore begins with precise definitions of the relevant terms for the product development process to be dealt with.

A product development process can be defined as a process which takes place in several stages (Figure 8.2).

[192] see page 24, footnote No. 48

[193] Comparing organisational structures with reference to Siemens' organisation, in: Automobil Elektrik, August 1997, p. 28; Bosch's divisions and management, in: Automobil Produktion, Juni 1998, p. 36; Visteon's organisation, in: Automobil Produktion, Dec. 1997, p. 64; The organisation of Valeo Germany, in: Automobil Produktion, Feb. 1996, p. 49; Pierburg divisions, in: Automobil Produktion, June 1996, p. 50; Rockwell International, in: Automobil Produktion, August 1997, p. 109

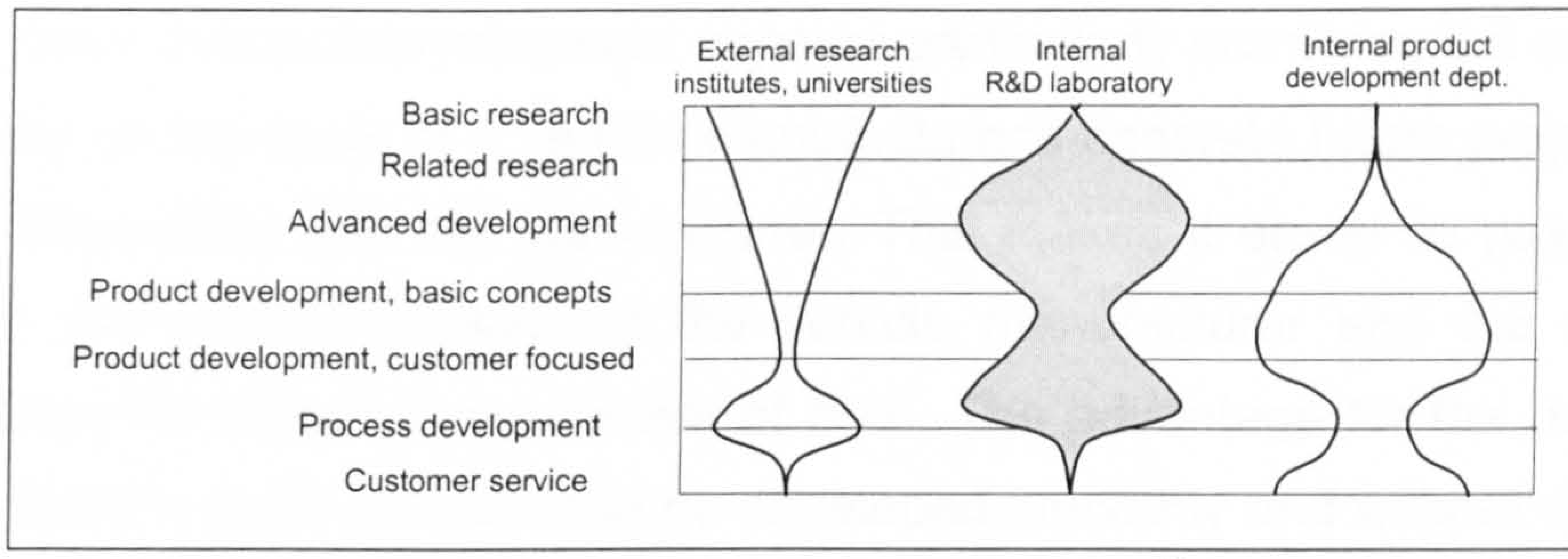


Figure 8.2: An example of a division of tasks[194]

Actual product development is preceded by research activities, which play a secondary role here, and begins with the advanced development stage. This stage in turn begins with a systematic analysis of technical possibilities and foreseeable or possible customer and market requirements, and is aimed at the development of new technologies, methods and materials. Development concepts which can be proven to have marketable potential are set aside to be converted into products. Independent advanced development is carried out primarily by system suppliers, depending on how well the complete system is understood.

At the basic concept development stage which follows, the general principles and performance parameters resulting from the advanced development stage are developed specifically with the aim of producing a marketable basic product concept. The basic processes necessary for subsequent production are developed in this stage along with the basic product concept so that production can take place later on at the intended production site facilities with minimum investment in materials and staff. Material specifications, permitted variances and tolerances are fixed, the relevant parameters for the most varied of production, assembly and test processes are specified and the necessary production facilities, tools and equipment are determined. Cost-effective production in the subsequent customer-specific serial production phase can be ensured by the system integrator attaching importance to the standardisation of sub-systems, components and specifications right from the start of concept development. Only this way, can

- consistent quality, despite global production and procurement,
- large batches, despite customer-specific solutions and
- minimum complexity, despite high product diversity

be guaranteed later on[195].

[194] See Otala, M., Innovatives Produktmanagement: Höhere Qualität und kürzere Entwicklungszeiten, in: Elektronik, No. 13, 1992, pp. 76-84

[195] See Schlonski, A., Engineering-Prozesse aus der Sicht eines Zulieferers, in: Automobiltechnische Zeitschrift, 1997, No. 4, pp. 190 - 198.

Generally, basic concept development appears particularly promising if it can take place directly on the basis of a vehicle manufacturer's concrete future project and in close collaboration with the manufacturer. This makes it easier to pay closer attention to the mutual interests of the vehicle manufacturer and the system integrator from the outset to the benefit of both. The advantage for the (system) supplier is that the basic concept can be developed smoothly and without delay to produce a vehicle application ready for the market. The first joint realisation of a (system) supplier's new product concept together with a vehicle manufacturer is therefore usually identical with the basic product concept.

There is a flowing transition from general basic concept development to concrete product development. The difference is that in product development, the emphasis is on the specific requirements of the vehicle manufacturer concerned, which the (system) supplier attempts to realise with a minimum of adjustments and changes to his basic product concept. The aim of product or application development therefore is to create product variants on the basis of an existing basic product concept, which satisfy individual customer requirements.

The experiences gathered in product development, from the different product variants and customer projects, modified customer requirements and new technological possibilities, are channelled into the ongoing development and optimisation of the basic product concept. This enables the (system) supplier to minimise the costs and work involved in adapting the different product variants still further in the future. Depending on product and market requirements, the supplier can follow a strategy of increasing the modularity and/or standardisation of his basic product concept. Improved modularity helps him to be more flexible and to react to different customer requirements at more frequent intervals; standardisation, on the other hand, makes it possible to reduce variant diversity. The optimisation phase is continued, provided that no better basic product concept or none to substitute for the existing concept is found.

Accordingly, further observations and investigations apply within the framework of the development process to the customer-specific application of an existing product concept and to product development on the basis of specifications provided by the automobile manufacturer - from the initial request for a quotation to SOP - against a background of increasing product integration.

8.2.2 Changing determinants of the product development process

The underlying conditions for a supplier's product development process which are summarised below are based on the observations outlined in Figure 8.3.

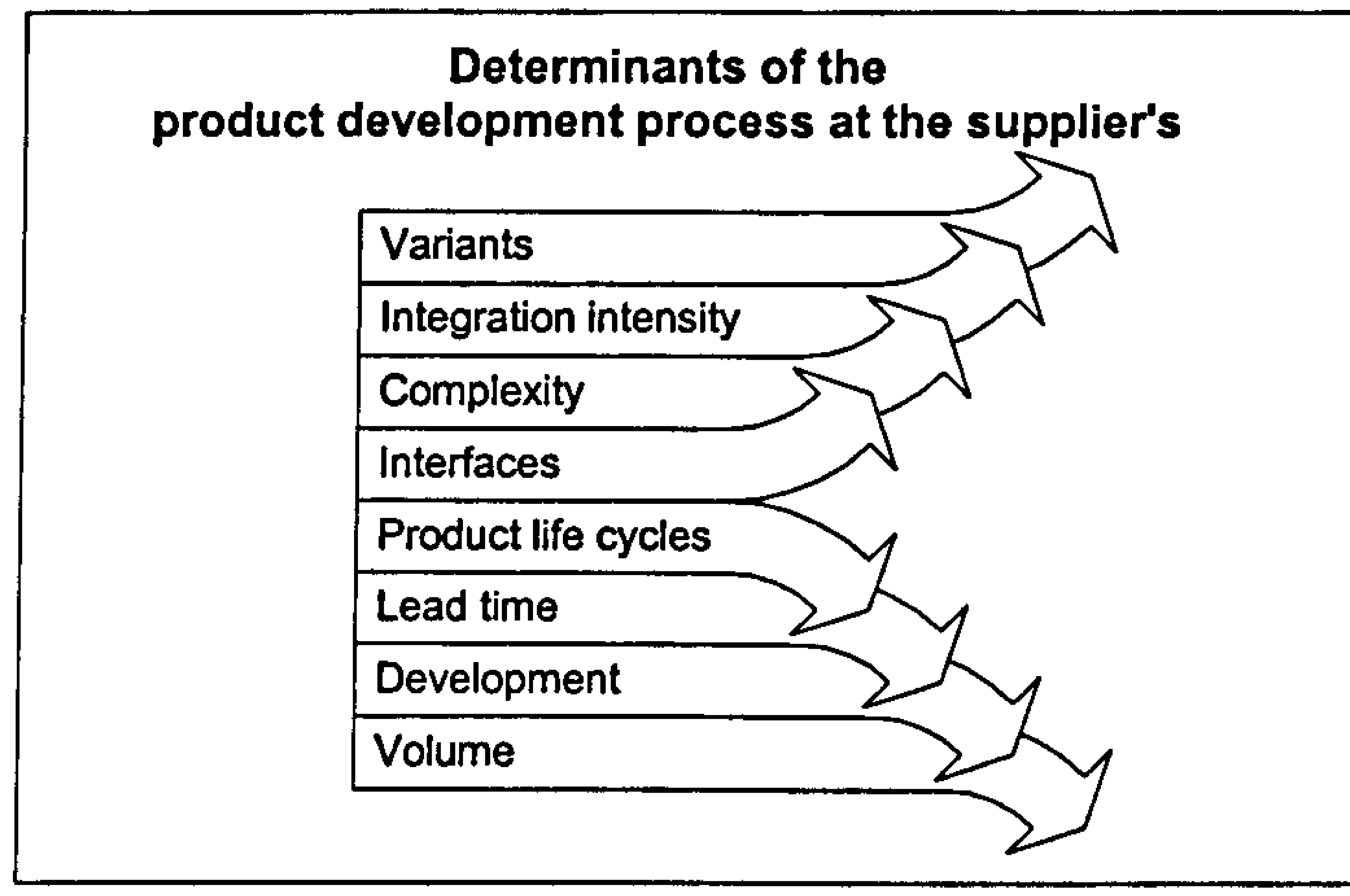


Figure 8.3: Determinants of the product development process

Variant diversity has increased substantially as a result of the rising demand for individual, customer-specific products. Vehicle manufacturers are reacting to the ever-faster changing customer requirements by changing their models at more and more frequent intervals. This has resulted in shorter product life cycles and a reduction in the production volume for each model variant.

With reference to the development process, this means that old products need to be replaced by new ones at more and more frequent intervals. Old technology and old design must give way to new technology and new design. If possible, however, the new product must be cheaper to produce or even more functional than its predecessor. Due to increasing integration, products are becoming increasingly complex for the system supplier, the number of interfaces and sub-suppliers to be co-ordinated is increasing constantly. At the same time, OEMs are exerting extremely high cost pressure on suppliers. This is heightened further by global competition and increasing development budgets for an increasing number of new products and more capital-intensive processes and methods[196].

This brings us to the following question: With increasing product complexity and integration (system building), how can new products be developed using a minimum of resources, at minimum cost and in as short a time as possible?

In order to get to the bottom of this, it is necessary first to take a brief look at the factors influencing the development process.

[196] Wildemann, H., Entwicklungsstrategien für Zulieferunternehmen, Forschungsbericht, Munich, 1993, pp. 72 ff.

The input factors of product development can be divided into two groups (Figure 8.4):

- Direct input factors (work, time, investment),
- Indirect input factors (tools, methods, strategy, culture, organisation, philosophy etc.).

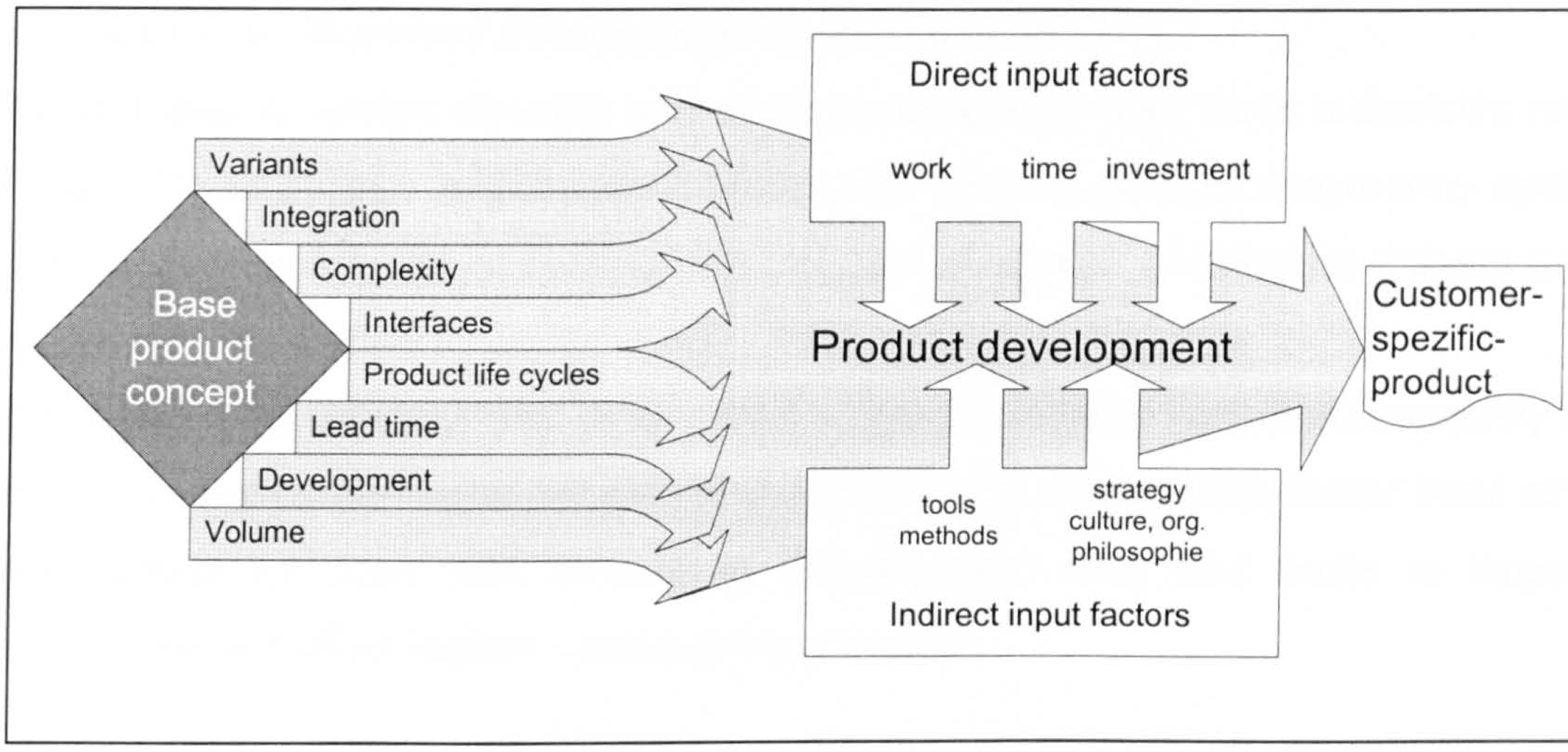


Figure 8.4: Input factors in the product development

The direct input factors work, time and investment are closely interrelated. An above-average increase in the input factors work and investment, without changing the usual processes, does not necessarily result in time savings. Total expenditure is relatively constant. According to LITKE, there is the following connection between project costs and project duration (Figure 8.5)[197].

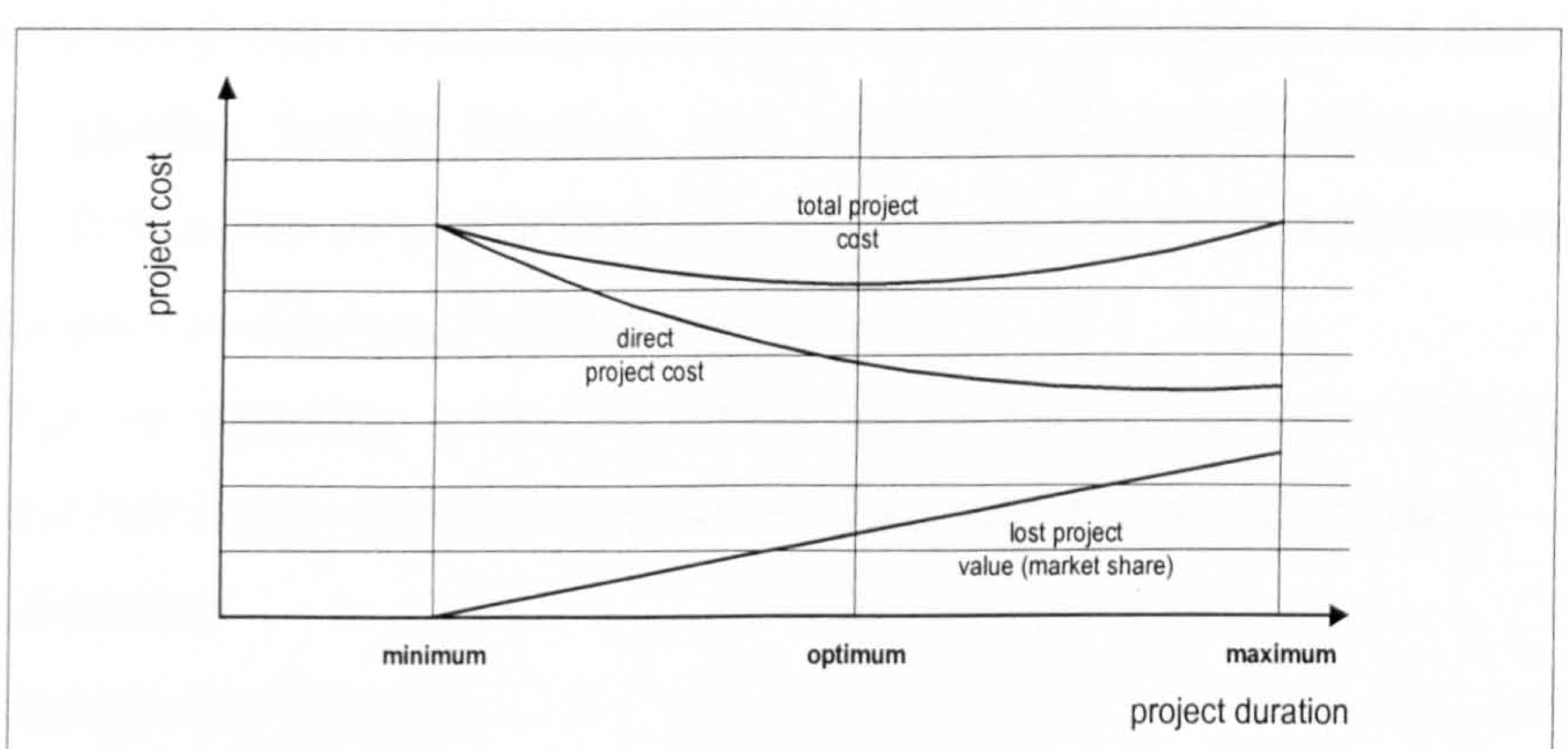


Figure 8.5: The correlation between project duration and project cost (source: Litke, 1993, in: Fricke/Lohse, 1997[197])

[197] See Friecke, G./Lohse, G., Entwicklungsmanagement: Mit methodischer Produktentwicklung zum Unternhemenserfolg, Berlin, Heidelberg, 1997, pp. 128 ff.

This representation makes it clear that a reduction in project duration to a minimum in the form of expensive bought-in services, overtime and increased project co-ordination leads to an over-proportional rise in direct project costs. However, this additional expense must be set against the advantages of an early market launch - market share, experience lead etc.[198]

It can be concluded that an increase in development input only appears to make sense in conjunction with the modification and reorganisation of usual business processes - i.e. "Business Process Reengineering" (BPR)[199].

The increase in variant diversity and product complexity also have a decisive role to play. These factors additionally increase the amount of time and money spent on development and are in conflict with the goal of shorter development times and low development costs.

The reason why development results and product concepts vary from company to company despite the same peripheral conditions and comparable factor input and how companies cope with increasing development time and costs is largely determined by further factors - indirect input factors.

Indirect input factors

Newly developed methods and tools - both standardised and specialist - are increasingly gaining in importance.

Companies are responsible for finding out which methods[200] and tools (archiving, data processing, management, design tools etc.) best serve their purposes and making them available to their employees. Effective utilisation is only guaranteed if these methods and tools are fully mastered by their users. The company should therefore not only make sure that constant updates take place, but also that users are given parallel further training and are kept informed of possibilities and resources. This is the only way that the use of such methods and tools can help to reduce development times and costs effectively.

Due to the far-reaching changes which have taken place in the automotive industry, the following indirect input factors also play an important role:

- Internal factors
  - corporate philosophy
  - corporate strategy

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[198] See Wildemann, H., Optimierung von Entwicklungszeiten: Just-in time in Forschung & Entwicklung und Konstruktion, Munich, 1993

[199] See Stürzl, W., Business Reengineering in der Praxis, 1996

[200] See Holst, J., Lean Development, 1995, pp. 130 ff.

  - corporate culture
- External factors
  - customer (needs, internationalisation)
  - competition
  - suppliers

While it is difficult for a company to exert a direct influence on external factors, internal factors can be controlled fully in keeping with market requirements. A system supplier, for example, which sets itself the goal of driving forward development in its particular business sector and launching innovative product concepts as quickly as possible must gear all internal factors toward achieving this objective.

Recognising the right market signals (external factors) and shaping internal factors accordingly is the task of management. With regard to product development, the management must provide the necessary support and initiative. The management must build up the necessary core competence and find the ideal combination of input factors. This includes technical equipment and the selection, combination and motivation of staff as well as constructive, market and customer-oriented organisation and corporate culture in order to make it possible to produce optimum development results, making the best possible use of intellectual and technical potential.

8.2.3 Organisation of product development

The environmental conditions of companies are changing at ever increasing speed. This means that more complex problems, which are also changing more and more rapidly, have to be solved. This poses a particular challenge in the area of organisation. Conventional task structuring according to Taylor can no longer be used to manage complex tasks such as product development, which calls for close co-operation among several departments in various organisational units. If such task structuring is applied, then the co-ordination involved is immense.

The increasing complexity of tasks, especially in the systems sector, must be taken into account by the choice of organisation structure.

Conventional organisational structures such as straight-line structures, line-staff structures, multiple-line structures and divisional organisations, can no longer meet demands as far as flexibility and dynamism are concerned[201]. Even currently widespread organisational structures such as matrix organisations or divisions with strategic business units (SBU) where the project manager function plays a dominant role in each case are rapidly coming under pressure[202]. In this context, FUJIMOTO's study provides a very impressive look at development effectiveness depending on organisation type - heavyweight, middleweight, lightweight, functional product manager[203].

The changing procurement landscape (system-building scenarios) and future requirements call for process-oriented organisation and project structures, in which experts from various disciplines and companies (Figure 8.6) come together in smoothly functioning interdisciplinary, creative teams[204]. These teams must operate independently within the scope of the agreed objectives and be fully responsible for their results. PROBST calls this the "heterarchy principle", which replaces the hierarchy principle. Decisions should be based on specialist knowledge instead of formal powers and made by the employees when they are needed.

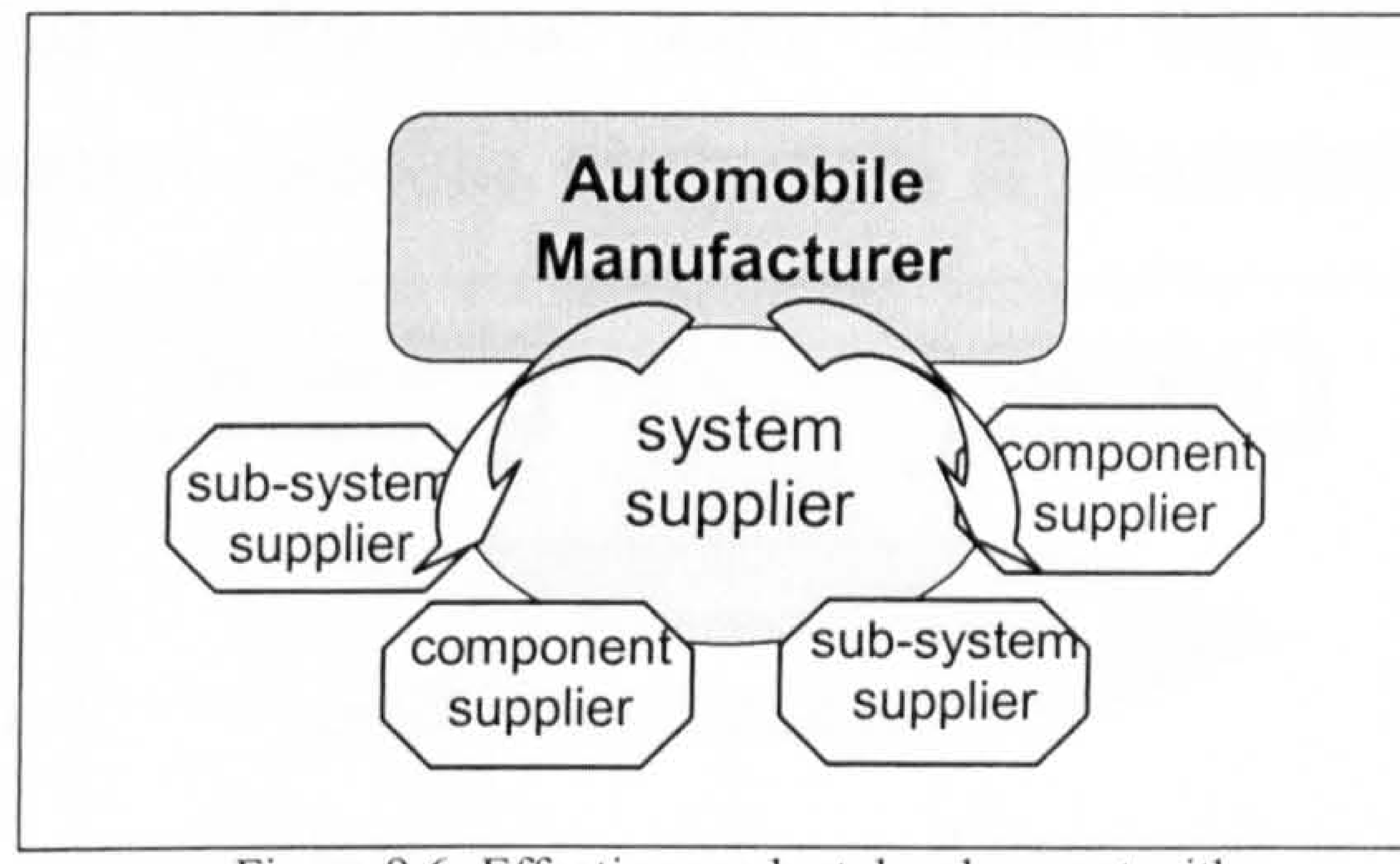


Figure 8.6: Effective product development with a flexible and dynamic team

"The aim of all organisational changes is to achieve the flexibility of small companies in large companies so that customer needs can be met quickly, cost-effectively and with excellent quality."[209]

[201] see Freiling, C./Kils, N.A., Organisation 2000: Die Erfolgsfaktoren schlanker Unternehmen, 1994
[202] See Clark, K.B./Fujimoto, T., Automobilentwicklung mit System, 1991, p. 248
[203] See Fujimoto, T., Organisation for effective product development, 1989, p. 460
[204] See Wildemann, H., Kernkompetenzen, 1996, p. 7, trend to virtual company

8.2.4 Changes within the product development value-added chain

Against a background of sustained competitive pressure, investigations conducted by DE MEYER have shown *"that well-organised business and development processes - value-added chain - can put a company ten years ahead of the competition depending on sector"*[205].

Compared with this, a new product produces about a three year lead on the competition, new process technologies a five year lead. Unlike the purely functional structure of process organisation, process orientation is characterised by the result-oriented uniting of different internal and external functions in a single project. EVERSHEIM names four factors of importance for an optimum process-oriented (development) process (Figure 8.7).

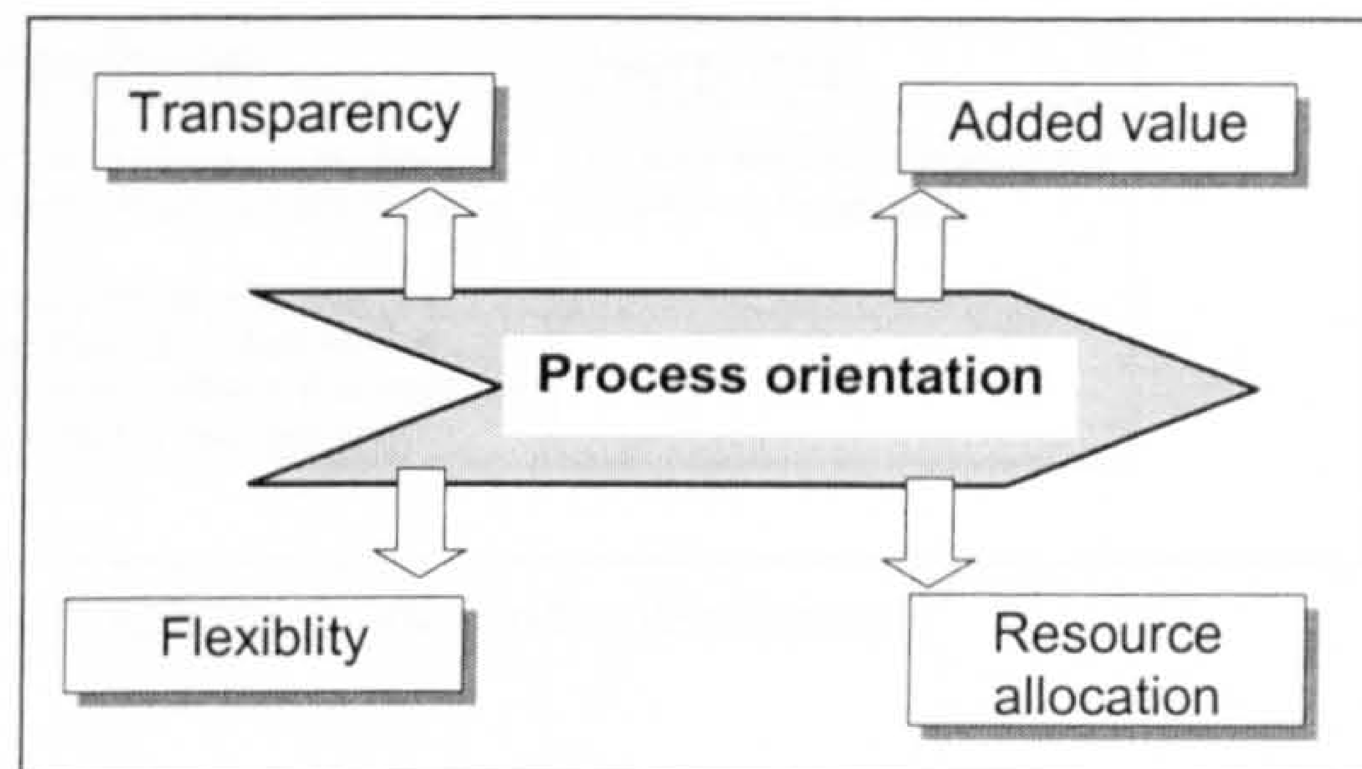


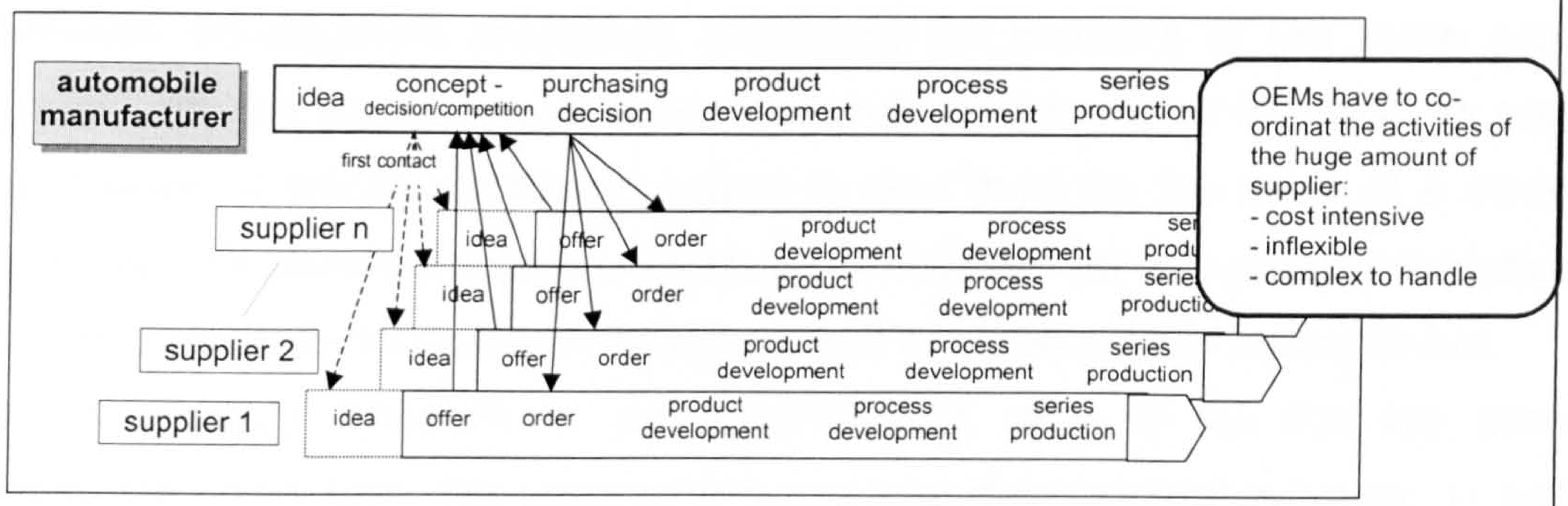
Figure 8.7: Important aspects for process orientation[205]

The decisive elements of process organisation are institutionalised by the interdisciplinary project team and the project manager. While the project team, with its flexible, project-specific line-up and creativity, counteracts a rigid, inadequate interpretation of the standard process, the project manager guarantees the necessary continuity and sustainment in the project process, regardless of function limits. He plans, monitors and controls all activities.

Another essential component of process-oriented process organisation is intensive project management geared toward the requirements and aims of the customer.

While earlier process structures were characterised by the fact that automobile manufacturers were responsible for the overall co-ordination of the development process with all its advantages and disadvantages (see Figure 8.8), manufacturers now aim to pass on these tasks to the system suppliers (see Figure 8.9).

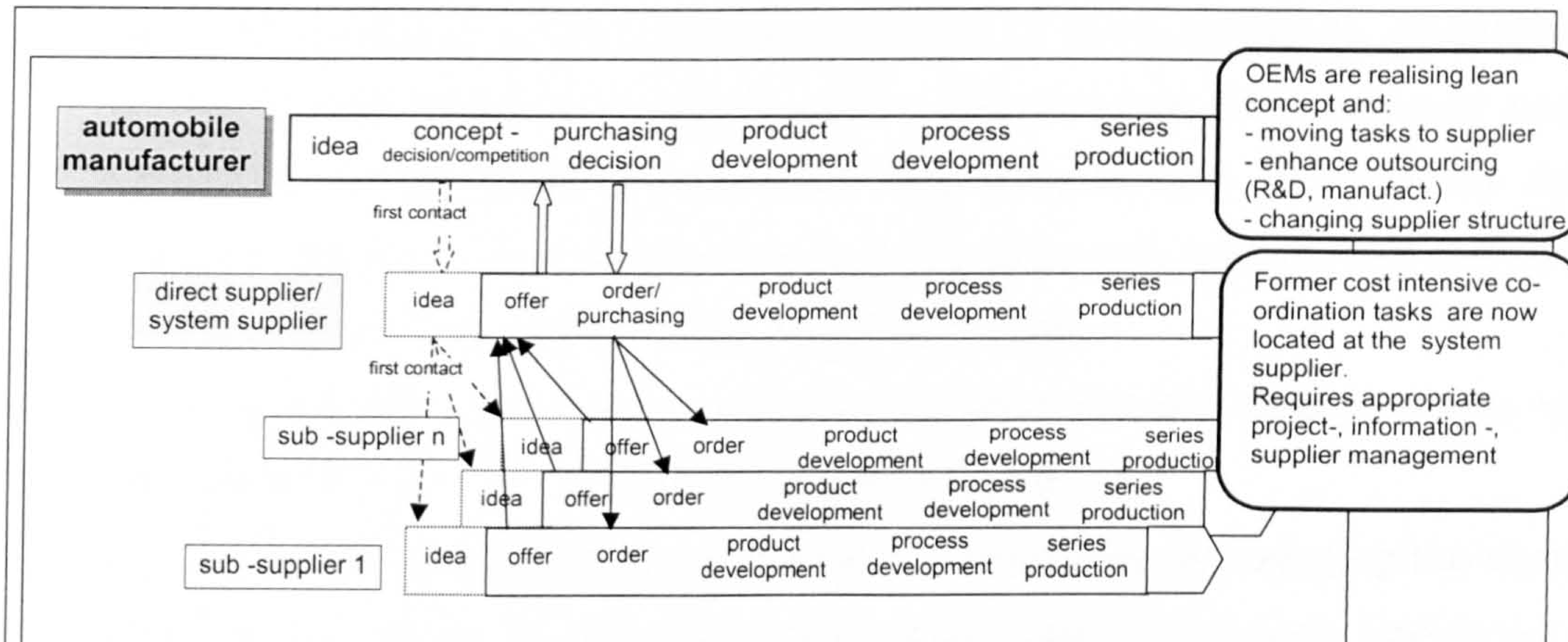
[205] See Eversheim, W. (editor), Prozeßorientierte Unternehmensorganisation, 2nd edition, Springer publishing, Berlin, Heidelberg, New York, 1996. p. 16



	Advantages	Disadvantages	Remarks
former value chain structure	- OEM can steer and control activities. - hardly no dependency on supplier can occur	- cost-intensive and time-intensive co-ordination of the huge number of direct suppliers - inflexible supplier structure - information flow controlled by the OEMs, sometimes renders it impossible to offer prevents the best solution	A more efficient value-added chain was necessary.

Figure 8.8: Previous value-added chain with reference to the product development

The system supplier takes on tasks such as project planning, management of the project, deadlines, change, information flow, costs and product integration as well as target management[206].



	Advantages	Disadvantages	Remarks
value-added chain based on system supply structure	- OEMs are becoming leaner as a result moving tasks to the system supplier. - OEMs are able to reduce risk (investment and development) - OEMs can concentrate on the core –competence Positive economic impact in terms of scale and scope - better information flow to the system supplier can lead to better quality, reduced lead time etc.	- system supplier becomes more powerful → dependency - waste of time as a result of staggered information flow OEM → system supplier → sub-system supplier	Early involvement of the system supplier. System supplier has to be able to take over former tasks of the OEMs and has to fulfil the requirements (see Chapter Five).

Figure 8.9: Development of the value-added chain based on the system`s supply structure

206 See Schernikau, J., R&D – Management for Modules and Systems

While every development process is generally unique, there are similarities between development processes, especially for products in the same product group, with the same product or technological complexity or in the same area of application. It therefore appears logical to plan them on the basis of a standard process. The standard process, which is not intended for any product in particular, can thus serve as the basis for flexible, result-oriented project management.

In this context, TANAKA Y. and BRITTON P. refer to the five key process elements which form the basis of a successful development process: 1) project approval, 2) continuous improvement, 3) project review process, 4) structured product development and 5) core team[207].

To conclude this topic, fundamental factors which can help improve process-oriented process organisation are described below.

- Instead of departments strictly co-operating on the basis of functions, as was frequently done in the past, the project team's work is results-oriented and process-oriented. This helps reduce development times, above all by avoiding unnecessary idle time and time spent on co-ordination and checking.
- As regard the efficiency of development processes, the MIT study places particular emphasis on the physical proximity of team members. According to the study, 80% of all innovations result from personal talks between people involved in the process, transcending departments and responsibility limits. However, the study also points out that these talks only take place if the people involved do not have to walk more than fifty meters.
- A further aspect regarding the reduction in development time concerns rapid information flow and short decision-making processes.
- The elimination of organisational interfaces, especially by reducing the division of labour, also helps to accelerate the decision-making process. Interfaces are only necessary if a particular employee reaches the limits of his authority and when it makes sense to align sub-activities of the overall project.
- The alignment of processes (simultaneous engineering) has the greatest potential for reducing development time. However, when comparing with sequential sub-activities, simultaneous engineering requires more organisational interfaces across which an increasing amount of information has to be exchanged. In this case, the risk of wrong decisions and repetition of

[207] See Tanaka, Y./Britton, P.L., Successful fabricator / supplier partnership through targeted product development, 1996, pp. M3-3

work already completed, which could prove costly, increases at a higher rate than the number of sub-activities which overlap (Figure 8.10).

- Due to the fact that more processes are carried out in parallel, internal and external support functions, especially suppliers, have to be involved in the development process at an earlier stage. Advance information, which can already be used by subsequent sub-activities before final approval, increases the potential for parallelism even further[208].

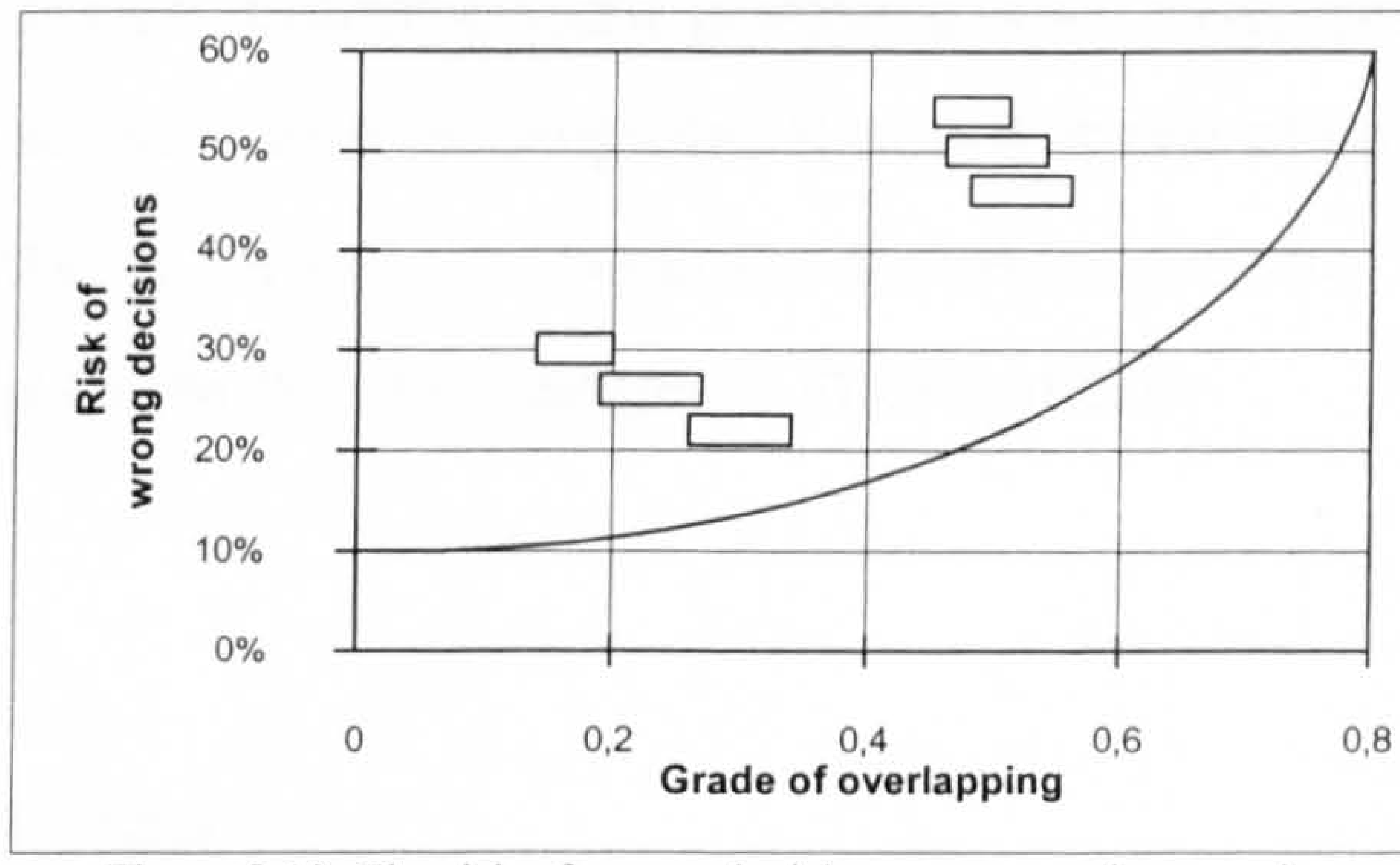


Figure 8.10: The risk of wrong decisions versus an increase in overlapping processes (source: Fricke, G., Lohse, G. 1997)

- In this connection, the organisation of efficient information flow is of special importance. Apart from the fact that information flows must be as open and direct as possible, as mentioned above, the choice of information medium and the means of communication also play an important role. "Media breaks" between participants often occur within the development process. Media breaks occur and are a disadvantage when the systems and formats used by participants to draft product or development-related data differ and cause additional work and costs. Not only do these media breaks only affect external areas (customer and sub-suppliers) - they usually occur within the different areas of a company[209]. Different hardware and software versions and a way of thinking which is restricted to a specific department are the causes[210]. Media breaks should be prevented where possible as they can hold up and complicate the development process. It is therefore a good idea to establish which systems and formats are used by participants at the start of a project and to then define which formats are to be used for project documentation and subsequent archiving.

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[208] See Henkel, C., 1996, p. 52, He stated in his work that the timing aspect for early supplier involvement addresses two important factors: a) identifying the right stage of the development cycle when a supplier's capabilities can be leveraged most, and b) determining the appropriate customer-supplier relationship that is required for this stage.

[209] See Vroom, R.W., described in his article, What is the information that should be generated by the engineering departments of automotive supplier companies, conference paper, 27th ISATA, 94ME031, 1994, pp. 413-420, which product information should be available when and how for an improved product development process, based on his information model by analysing the product development process at three Dutch automotive supplier.

[210] See Eversheim, W., 1996, p. 120, He mentioned that over 50% of the occurring problems during the product development are related to individual behaviour problems and not to factual problems like overengineering, unclear goal setting, unclear interface etc.

- Furthermore, the choice of means of communication[211] is becoming an increasingly decisive factor. In view of continuing globalisation and increasing complexity in the development process, development partners and customers must work together as intensively as possible in projects. Since it is not always possible for the main participants to meet in person, suitable means of communication should be used to ensure the exchange of information.

8.3 The investigation

8.3.1 Research methods and implementation

Taking account of the results of the theoretical analysis, a parallel attempt was made to add a practical aspect to the topic at hand. The obvious way of doing this was to include and interview the people involved in the development process. The impressions thus acquired provided a good overview of the current situation concerning the process-oriented development process.
The results and impressions thus acquired served as a basis for the preparation of a written questionnaire (see Appendix B). The aim of the questionnaire was to start out from the current situation and paint a statistically more meaningful picture of key competition factors with regard to increasing product integration, complexity and greater time pressure and cost pressure. Questions were asked on a wide range of aspects concerning all areas of the development process:

- Situation and significance of external interfaces between customers and supplier
- Use of process methods by the customer
- Flow of information to the customer and supplier
- How are development activities started, clarification of product requirement
- Methods and tools for increasing the efficiency of development processes
- Project team: line-up, authority, internal support
- Current project process: cost-related decisions, changes

The selection of participants and the sample was deliberately carried out according to subjective criteria. Taking account of the core competence of the investigated supplier, the sample refers in particular to the area of

[211] See Hauber, C., Team: Telecollaboration Applied: The new working paradigm of concurrent virtual enterprises in the automotive industry, conference paper, 18/19 Feb. 1997, Stuttgart

electronics system development. Project managers were selected as participants. The reason for selecting the project mangers as participants is that they represent the point of view of the entire project team and the development process. They are involved in all project-related activities and decisions, have technical responsibility and budget responsibility for the project and an overall picture of all project-related issues. Therefore, they are best informed on the project's weaknesses and strengths as well as future important changes and improvements.

The project managers selected for the questionnaire came from a wide variety of areas - Powertrain, Safety, Body Electronics, Chassis - and from different development locations (Germany, France, USA, Korea, Japan). This was done in order to cover more technological areas, which might have different ways of approaching matters, and to cover more regions so as to reduce cultural influences. The range of the project are covering by a comparable percentage both the system, sub-system as well as the component area.

37 of the 54 project leaders contacted took part in the survey and sent back the written questionnaire. The participants were only contacted personally in cases of unclear responses. This response rate confirmed just how much interest there is in further improving interaction between customers and suppliers in the development process.

8.3.2 Visualisation and method of analysis

The results were presented in descriptive and explorative form. Question groups (1) - (3), (6) and (7) were rated using a standard scale. Participants were asked to indicate the current status in each case and to specify the future importance of each aspect taking account of increasing complexity and greater cost pressure and time pressure. The scale for assessing the current status was divided into six levels ranging from "unsatisfactory" = 1 to "excellent" = 6. The scale for ranking importance was divided into four levels ranging from "unimportant" = 1 to "very important" = 4. Question groups (6) and (7) also

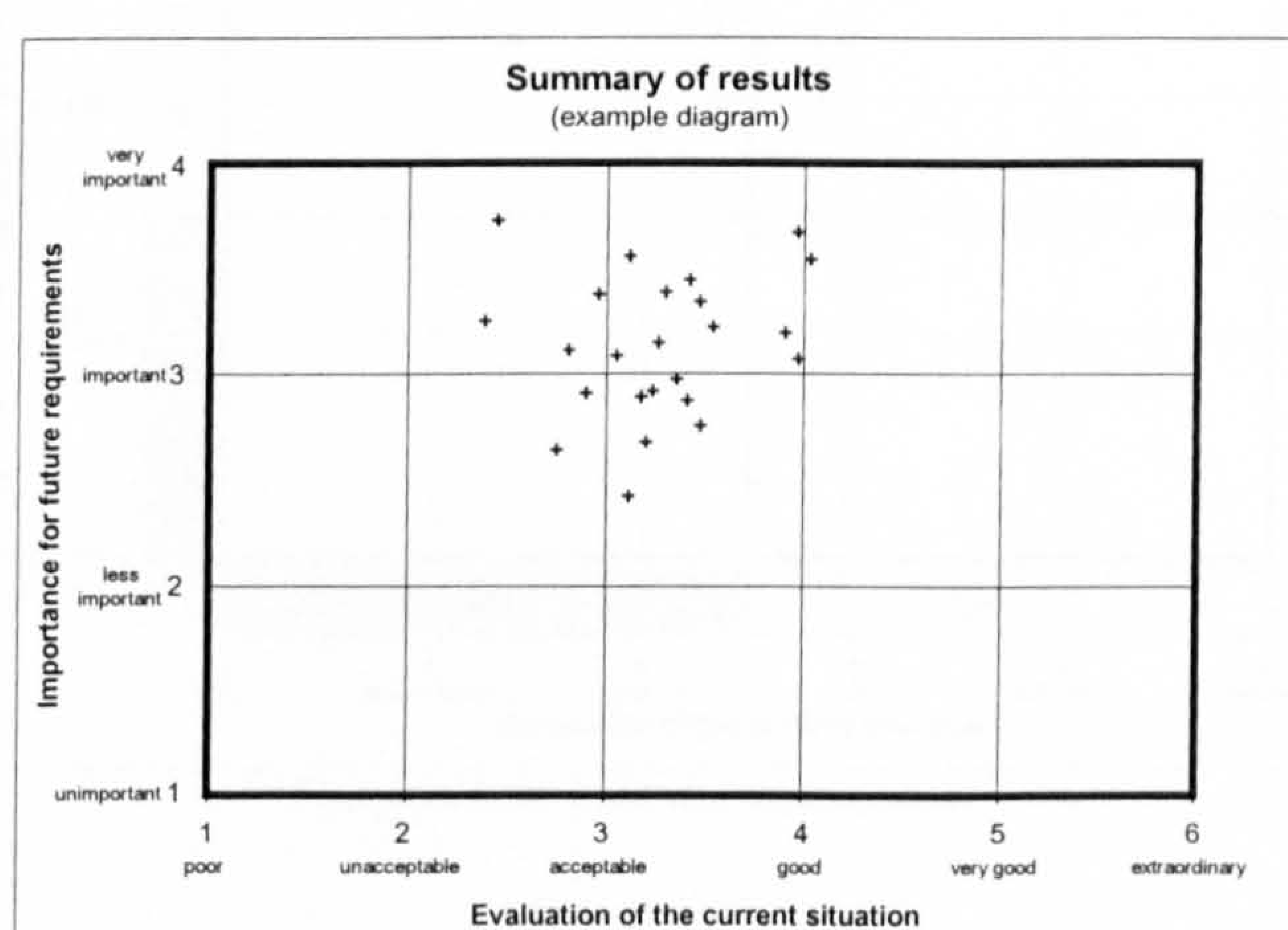


Figure 8.11: Summary of results

gave participants the chance to express personal views and ideas in addition to providing data for the statistical analysis. Suitable answers were taken into account in the descriptive presentation.
As more than 200 answers per questionnaire had to be evaluated, it was considered appropriate to summarise the large volume of data systematically in diagrams on the basis of calculated mean values for the current status and the importance of future competition factors (Figure 8.11).

In addition, the *empirical standard deviation (s)*[212] was calculated and specified in accordance with the classification. The standard deviation indicates to what extent the answers provided by participants agree or differ. The smaller the value, the greater the agreement and thus the more reliable the statements.
In the case of question groups (4), (5) and (8), participants were also requested to weight certain aspects in percent. To evaluate these answers, the results were classified for calculation and presentation of the percentage distribution, the arithmetic mean and the standard deviation.
The individual mean values were assigned to the diagrams in accordance with the subdivision of the question groups agreed beforehand. In most cases this produced a cluster of points located in the top half of the "Importance" axis and relatively central on the "Current Situation" axis.
Interpretation of the various aspects was complicated by the fact that the points were so close together. It was necessary to find a way of distinguishing between the points both individually and in relation to each other in order to establish the appropriate need for action. After all, the analysis was aimed at making maximum use of the project managers' experience and ideas to deduce practical recommendations for future improvements to the development process.

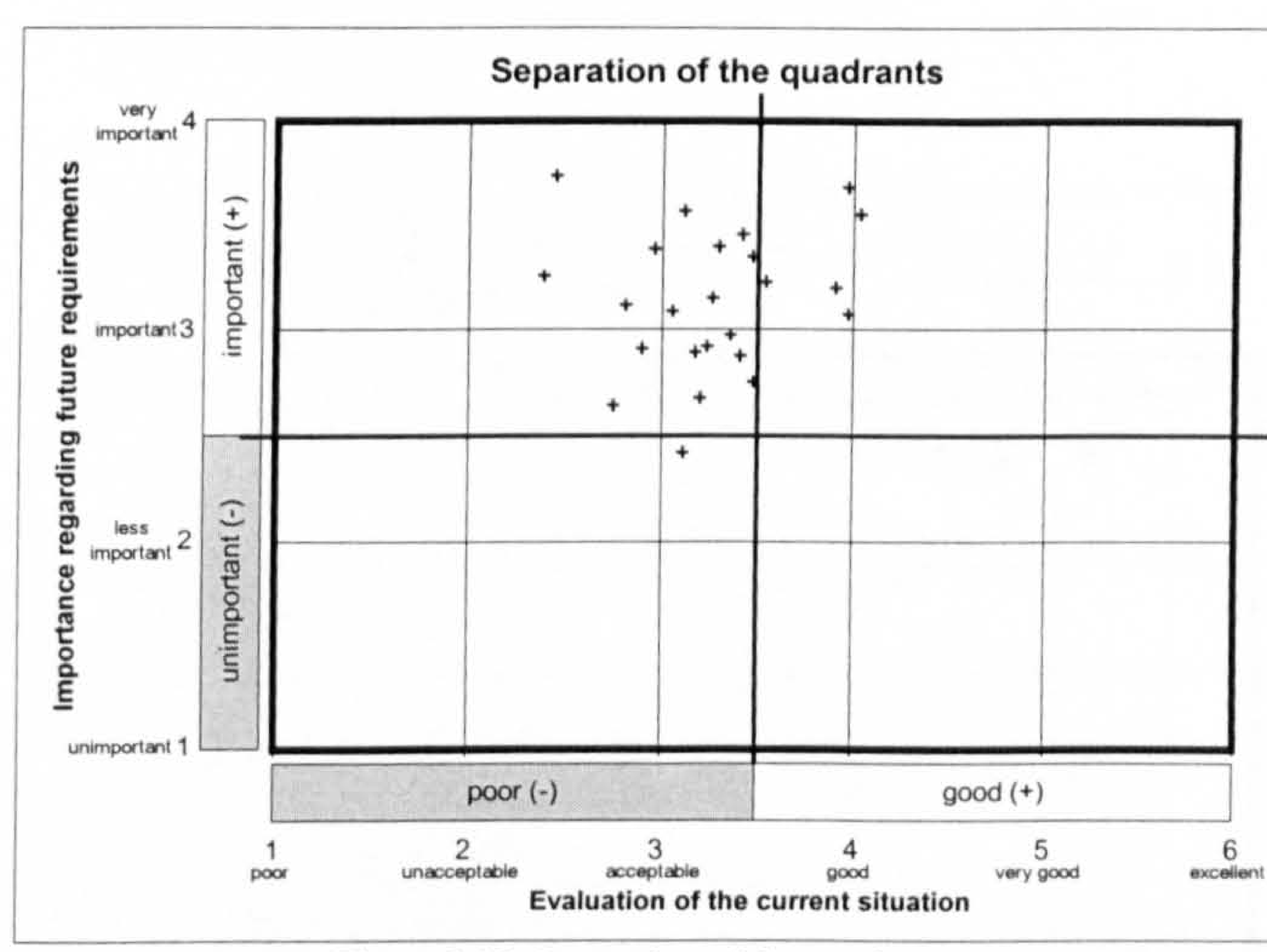


Figure 8.12: Separation of the quadrants

A method of analysis, which may be described as a kind of

212 see Bamberg, G./Bauer, F., Statistik, 7th edition, R. Oldenbourg publishing, München, Wien, 1991, pp. 21-23

portfolio analysis, was developed against this background. The aim of this method is to deduce an optimum situation and the corresponding need for action based on the position of the point in the graph. The diagram was first divided into quadrants (Figure 8.12).

All co-ordinates smaller than 3.5 on the "evaluation" axis, i.e. those classified between poor (1) and acceptable (3.5), are defined as "worse evaluation"; all co-ordinates above this are defined as "good evaluation". Correspondingly, on the "important" axis, all values smaller than 2.5 are "unimportant" and all values greater than 2.5 are "important".
This already produces a differentiated picture. It shows that although a large number of the values in Figure 8.12 are important, the majority of participants gave a poor evaluation of the current situation. It can thus be concluded that measures need to be introduced to improve individual aspects taking account of their importance. The aim must be to achieve a position in the top right quadrant.
Depending on the importance of the aspect concerned, there is an optimum value for each point. This optimum is calculated based on the ratio of axis divisions and the importance value.

Calculation

Required action: $R_{action} = e_{optimum} - e_{current}$

evaluation optimum: $e_{optimum} = \frac{ARv * (i - 1)}{ARi} + 1$

or: $e_{optimum} = \tan\alpha * i_{current}$

importance = i

evaluation = e

axis-ratio importance: ARi = (4-1)

axis-ratio evaluation: ARv = (6-1)

angle α = 30.9°
(partition x axe = y axe)

The optimum status is on the diagonal in each case (see Figure 8.13).
The difference between the current status and the theoretical optimum status is shown by the arrow. The longer the arrow, the greater the assumed need for action. It may thus be concluded that

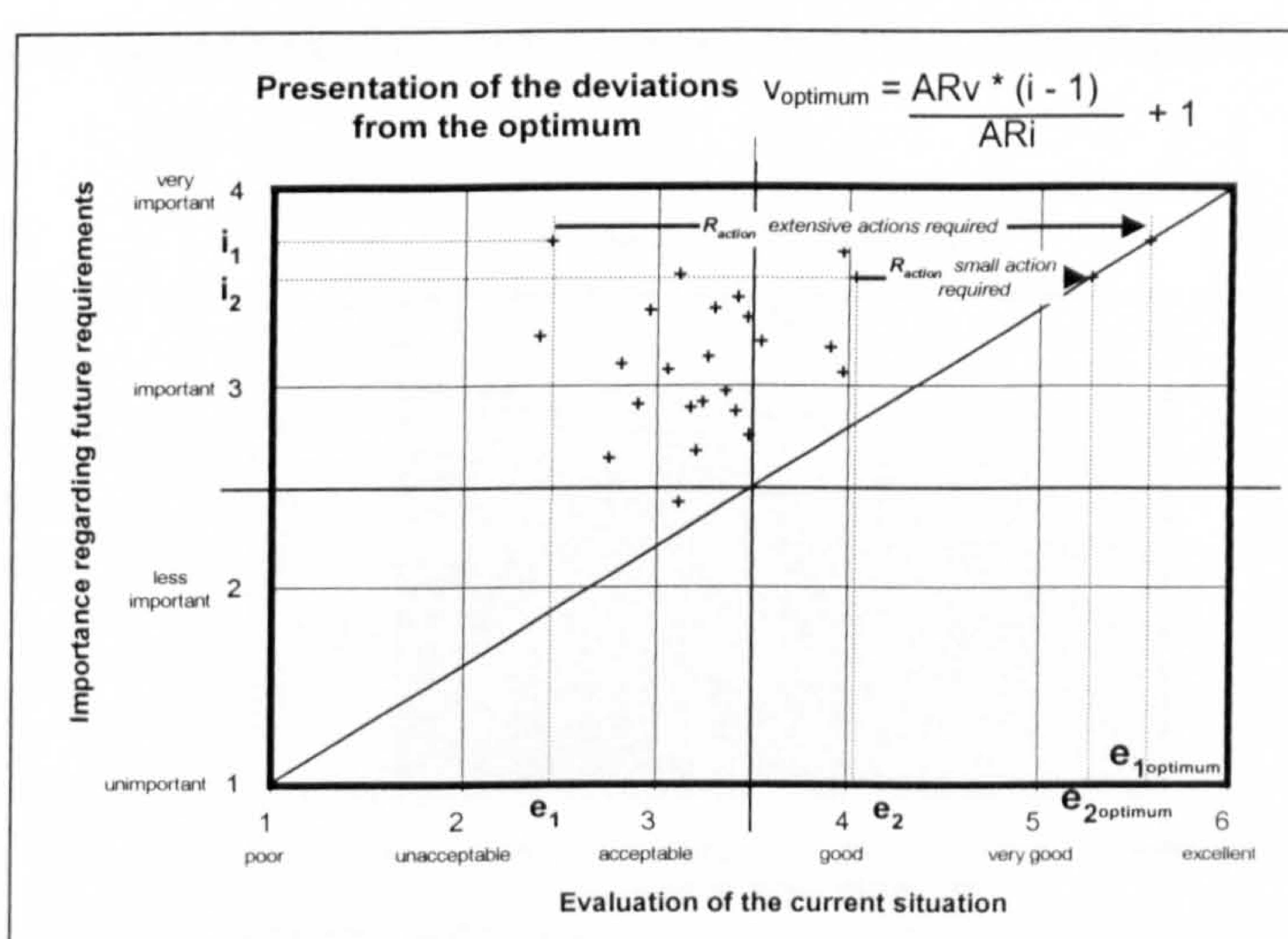


Figure 8.13: Presentation of the deviations from the optimum situation and scope for action

the aspects with a greater difference between the current situation and the optimum situation should be given greater priority than the aspects with a smaller difference. The diagonal also has another function: It divides the diagram into an upper and a lower section.

If a point is situated above the diagonal and the arrow is pointing to the right, this means that the current status is worse than the optimum status. Measures must therefore be taken to improve the current status. However, if a point is below the diagonal and the arrow is pointing to the left, the current status is better than the theoretical optimum. It can therefore be concluded that too much is invested in things which are considered less important. It is therefore necessary to consider whether it is practical to continue investing such time and money in these areas. The need for action should be limited to the formula: "Less is more". The following "strategy aspects" can be derived (Figure 8.14) depending on quadrant and position (above or below the diagonal).

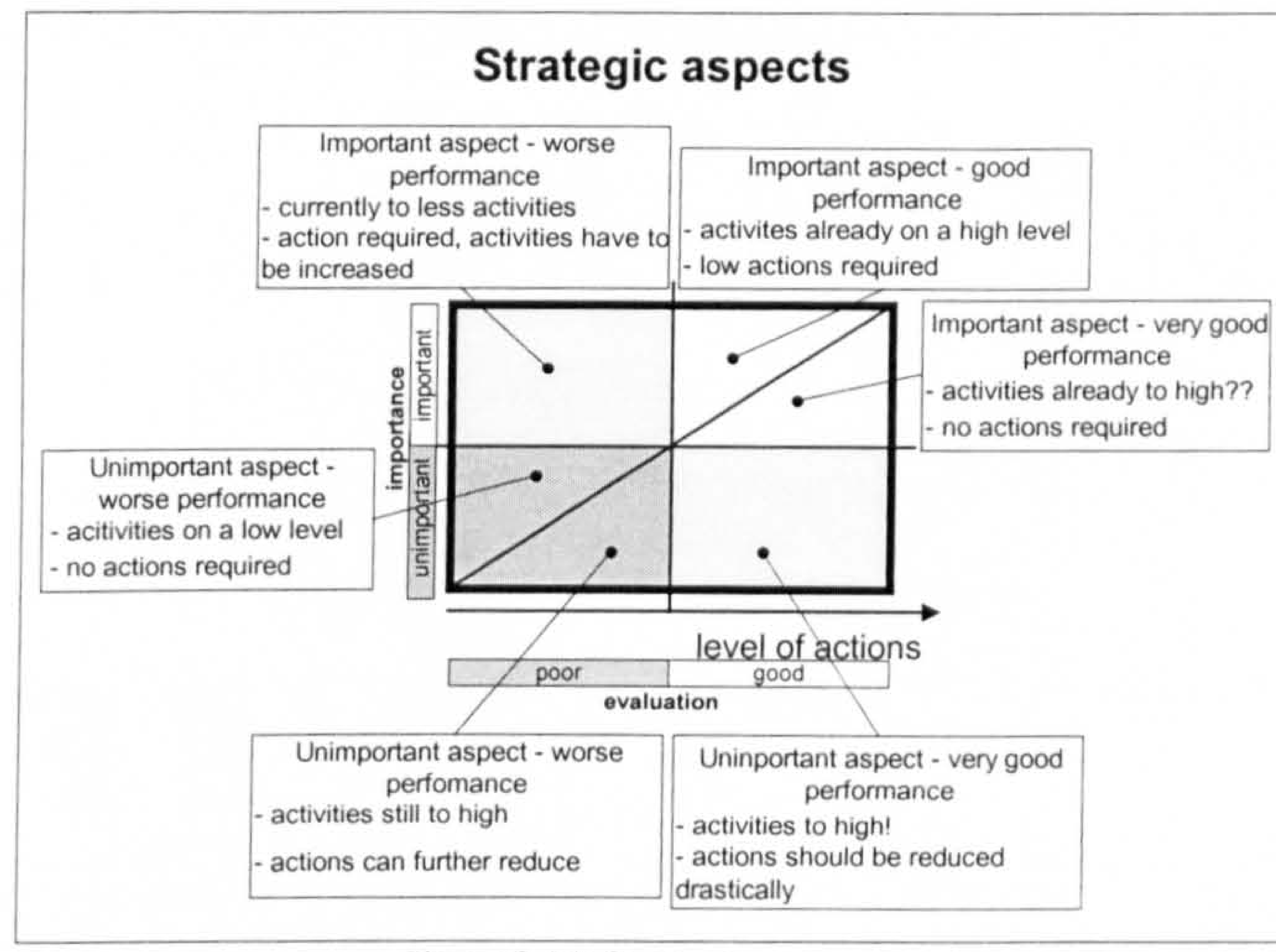


Figure 8.14: Strategic aspects

Following the "standard" strategies approach, the "important" aspects in the upper quadrants are particularly interesting in practice, especially those with further potential for improvement.

In order to make the situation even clearer, it makes sense to introduce further gradation in accordance with the importance of the various aspects (see Figure 8.15).

Gradation I
- decisive competition factor
- required actions high priority

Gradation II
- important competition factor
- required actions medium priority

Gradation III
- important but not crucial factor
- required actions low priority

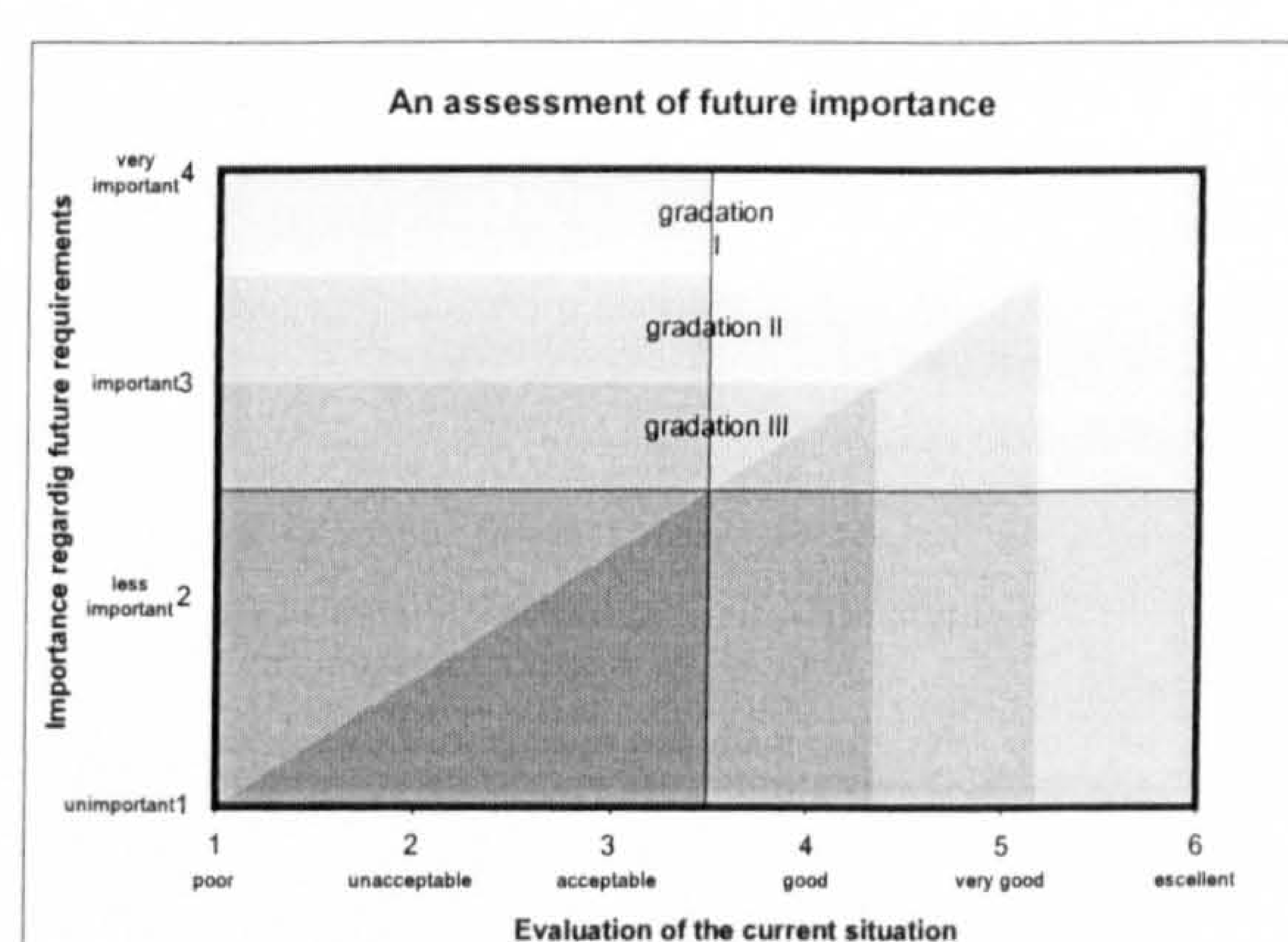


Figure 8.15: An assessment of future importance

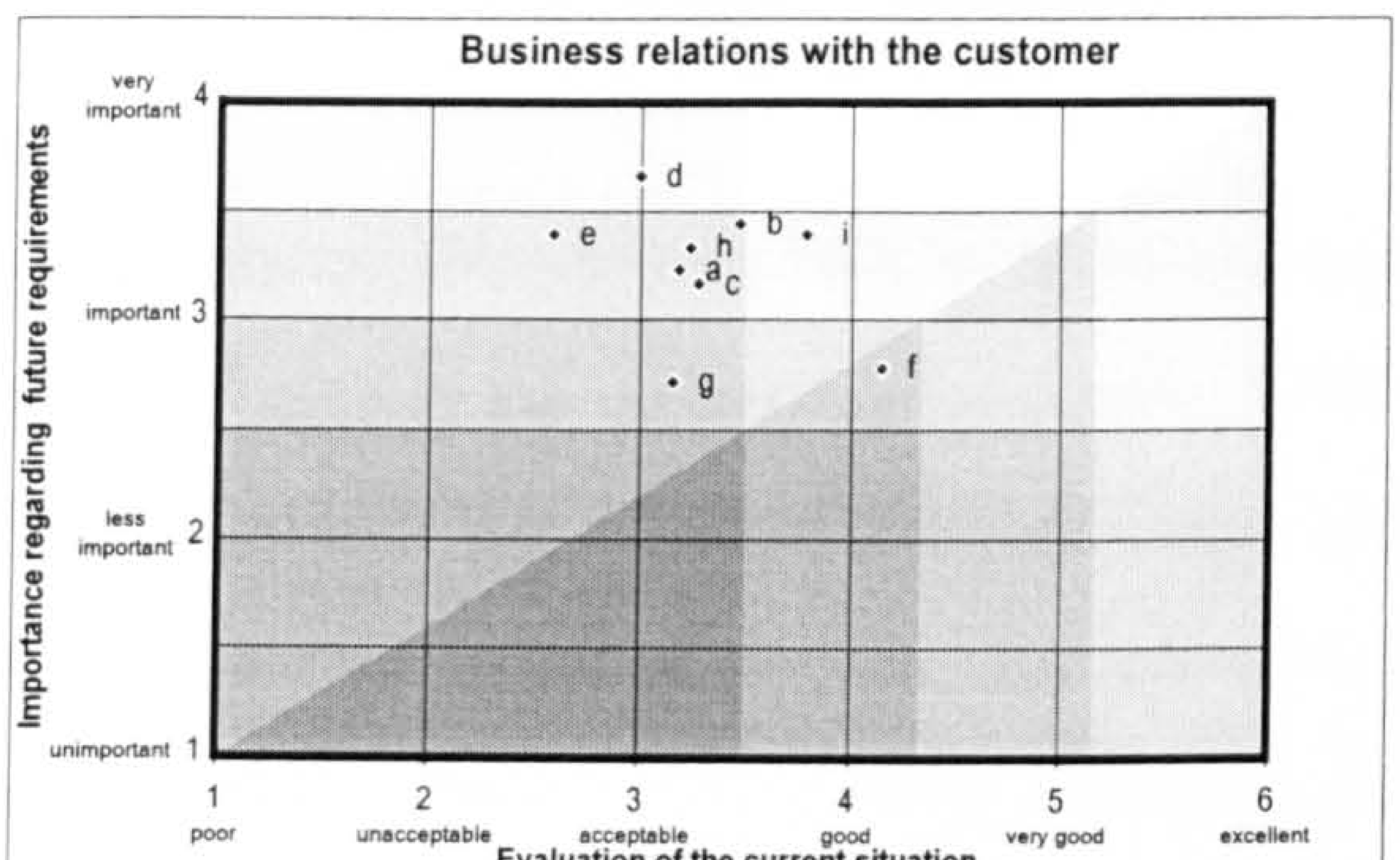
This method of analysis is based on simple mathematical and logically comprehensible interrelations.

It allows the user to allocate appropriate strategies depending on the position of the point concerned without having to perform any complicated calculations.

8.4 Analysis and interpretation of results

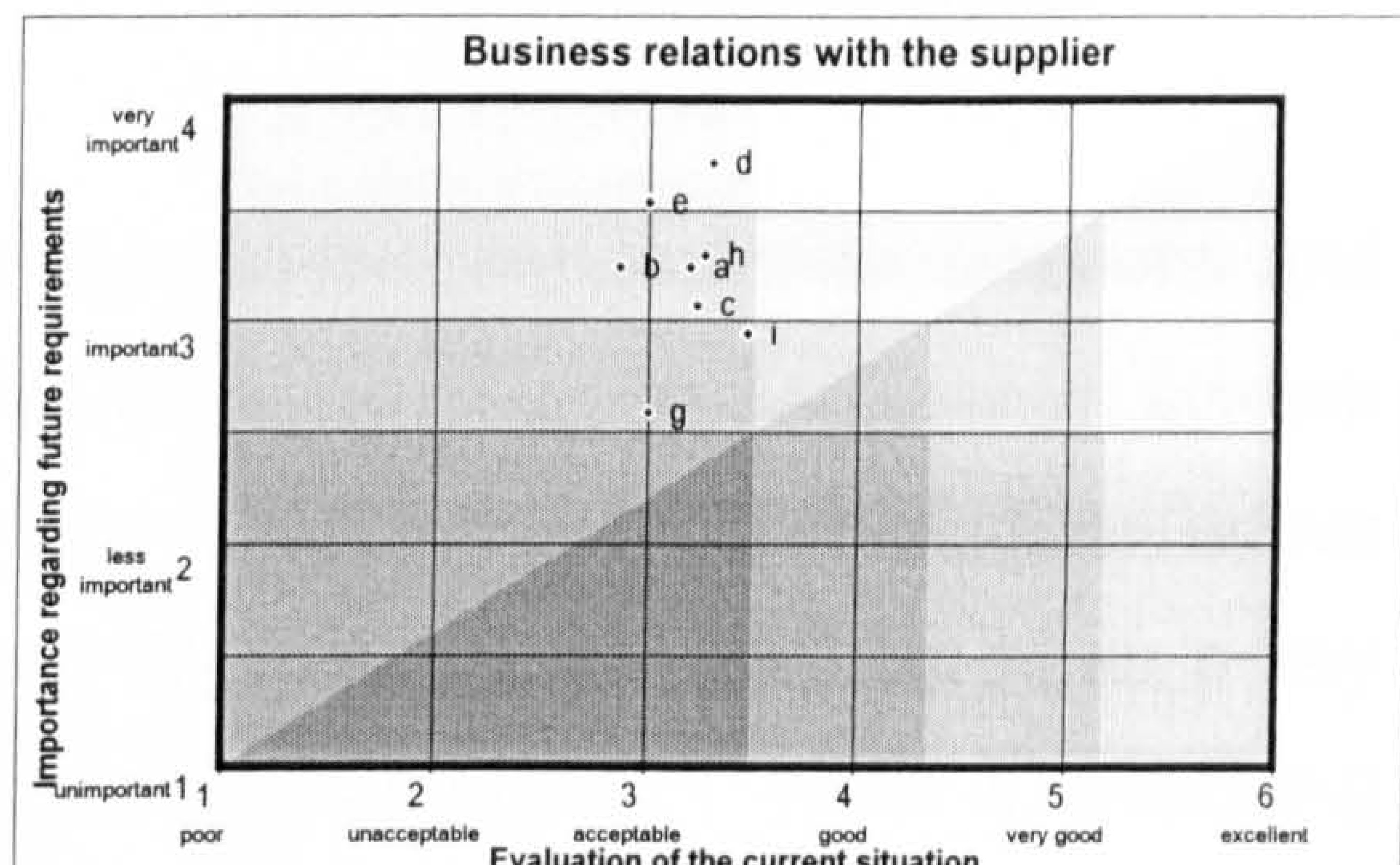
8.4.1 Evaluation of internal and external interfaces

One of the most important aspects concerning the process-oriented development process is the relationship to the customer and sub-suppliers. Taking account of the restructuring of the suppliers pyramid and increasing product integration in particular, it was interesting to find out about the relationship and co-operation between the company under examination and its customers and sub-suppliers.



Index	Evaluation of the business relations with the customer (OEM) concerning following aspects:	evaluation	standart deviation	importance	standart deviation
a -	Early supplier involvement in future development projects	3.18	1.29	3.22	0.53
b -	Trust	3.47	1.01	3.44	0.60
c -	Willingness to compromise	3.27	1.21	3.17	0.69
d -	Reliability regarding made commitments	3.00	1.24	3.67	0.58
e -	Reliability regarding milestone settings	2.59	1.31	3.39	0.49
f -	Easy to contact	4.15	0.94	2.78	0.53
g -	Equal partnership	3.15	1.23	2.72	0.56
h -	Interface definition	3.24	1.19	3.33	0.67
i -	Intention of a long-term relationship	3.79	1.35	3.39	0.59

Figure 8.16 Business relations with your customer



Index	Evaluation of the business relations with the supplier concerning following aspects:	evaluation	standart deviation	importance	standart deviation
a -	Early supplier involvement in future development projects	3.20	0.98	3.24	0.55
b -	Trust	2.78	0.81	3.24	0.64
c -	Willingness to compromise	3.23	0.80	3.06	0.75
d -	Reliability regarding made commitments	3.30	1.00	3.71	0.46
e -	Reliability regarding milestone settings	3.00	1.08	3.53	0.50
g -	Equal partnership	3.00	0.77	2.59	0.49
h -	Interface definition	3.27	0.81	3.29	0.57
i -	Intention of a long-term relationship	3.47	0.81	2.94	0.54

Figure 8.17: Business relations with the supplier

Figures 8.16 and 8.17 provide an interesting overview of the current situation and the importance of individual factors. The relationship to the customer is seen to differ somewhat from that to sub-suppliers.

This can be explained in part by the fact that every development process is tailored to special needs and must cater for the individual requirements of the OEMs concerned. Nevertheless, several interesting aspects can be highlighted on both sides. The majority of participants, for example, rate reliability concerning agreements concluded (d) as by far the most important factor. The current situation, however, was only rated on average as "satisfactory". This is due to frequent and above all late changes to the specification, as shown in Figure 8.18 based on the example of the customer. This aspect along with the sub-suppliers' inability to meet deadlines (see Figure 8.19) are a direct hindrance to internal project processes.

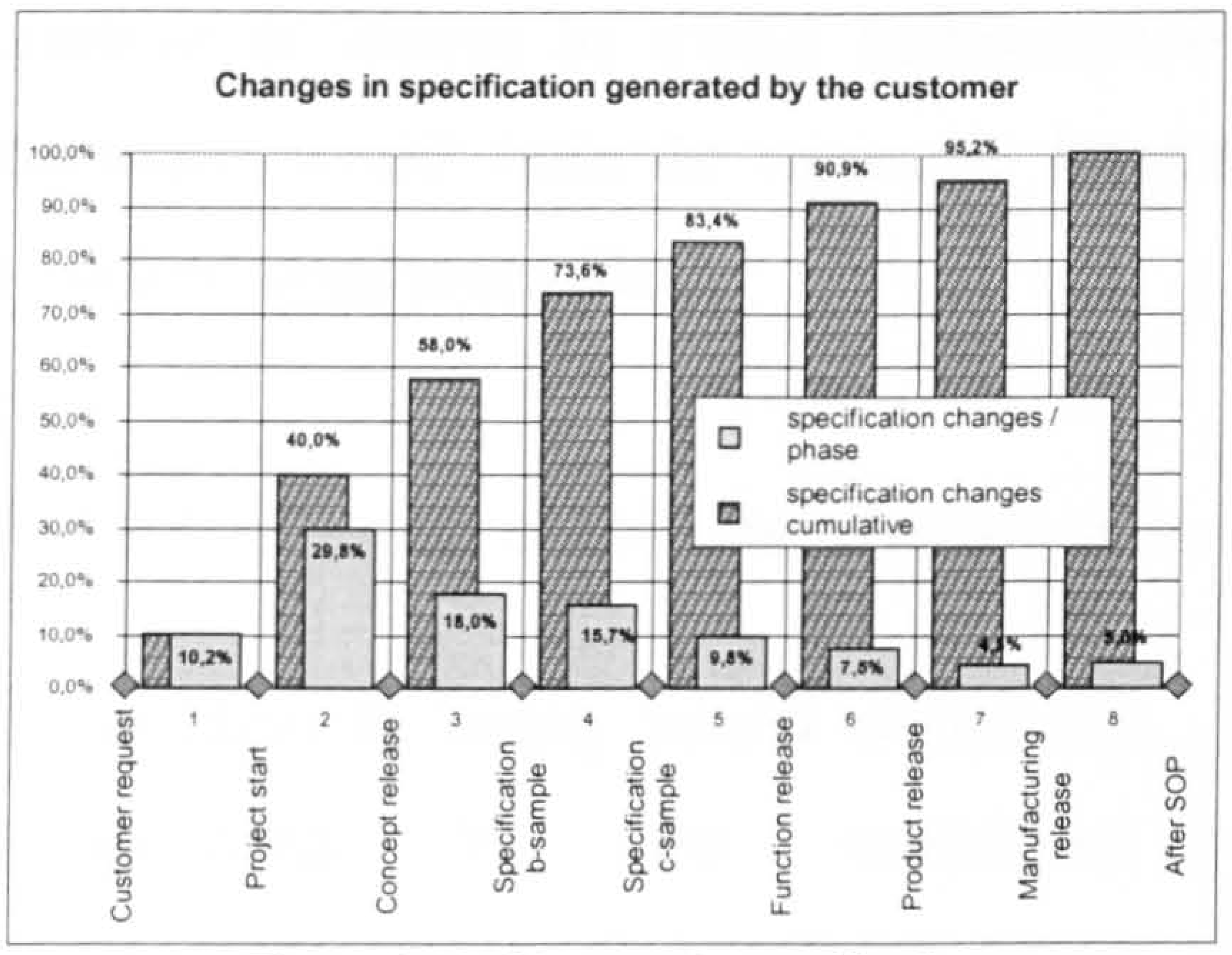


Figure 8.18: Changes in specification generated by the customer

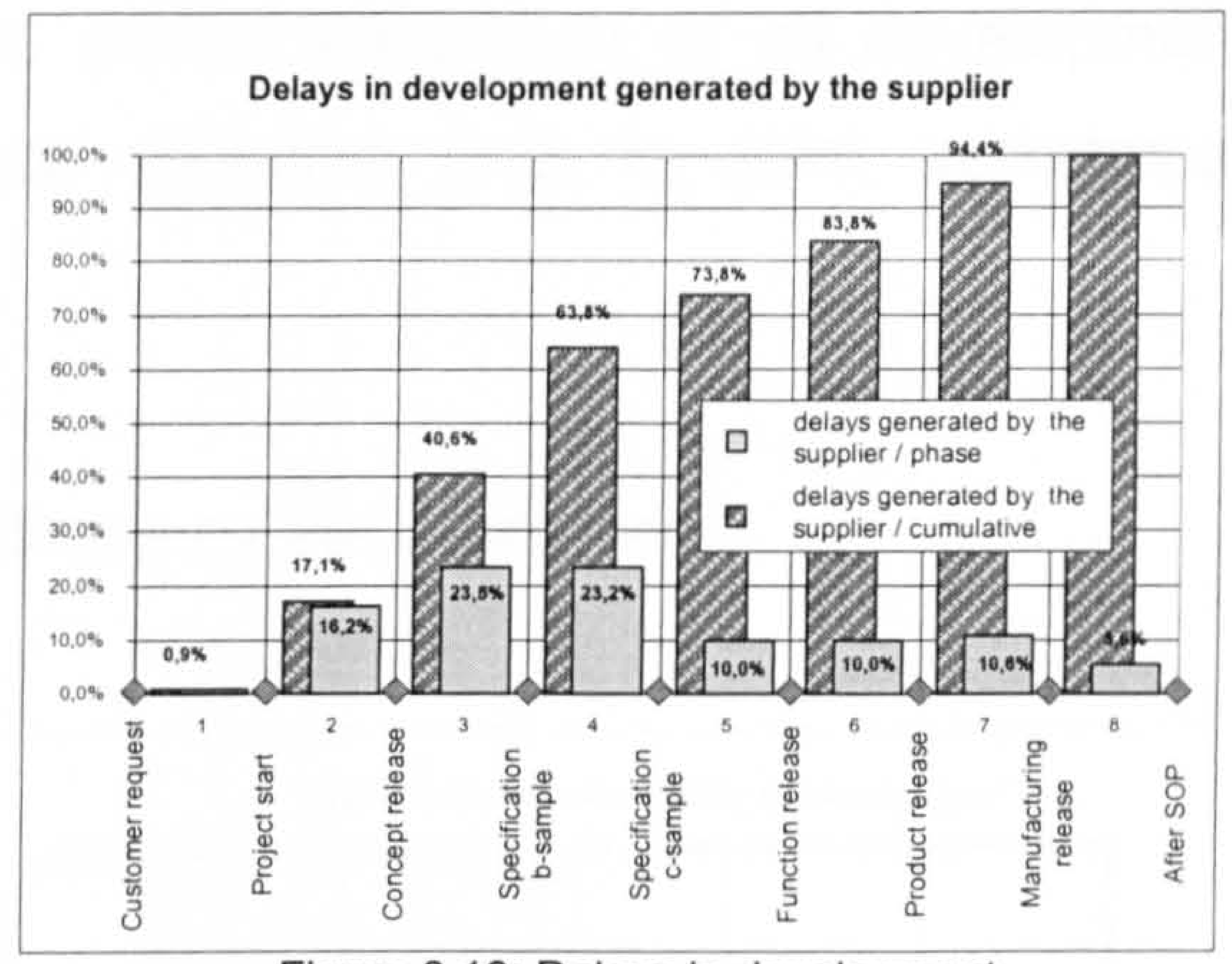


Figure 8.19: Delays in development generated by the supplier

Late changes and the failure to meet deadlines cause unnecessary iterations and delays along the entire value chain. This could be avoided if the customer, system supplier and the most important sub-suppliers in the group were to perform active change management. This fact was already identified in the MIT study as a key competition factor for up-and-coming Japanese automakers[213]. What is surprising is that there is still considerable room for improvement in this area.

The aspects trust (b) and the intention of a long-term partnership (i) provide an interesting picture. Rated as good but still in need of improvement as far as the relationship to the customer is concerned, they are considered less important in the relationship to the supplier, and trust in particular is rated as very poor[214]. This confirms the trend toward a closer and more long-term partnership between OEMs and their system suppliers[215]. This trend is not continued within the value chain between system and sub-system supplier, and excludes the component supplier in particular. This relationship is based more on flexibility than on a long-term partnership. This strategy is certainly advantageous for simple parts and components, but is a disadvantage for bought-in core components, because distrust and uncertainty stand in the way of close co-operation. Future procurement policy should certainly take this into account.

The aspects of early involvement in future development projects (a), a willingness to make compromises (c) and interface definition (h) are still in need of improvement both in the relationship to the customer and to suppliers.

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213 See Womack, L.P./Jones, D.T./ Roos, D., The Machine that changed the world, 1990, p. 118

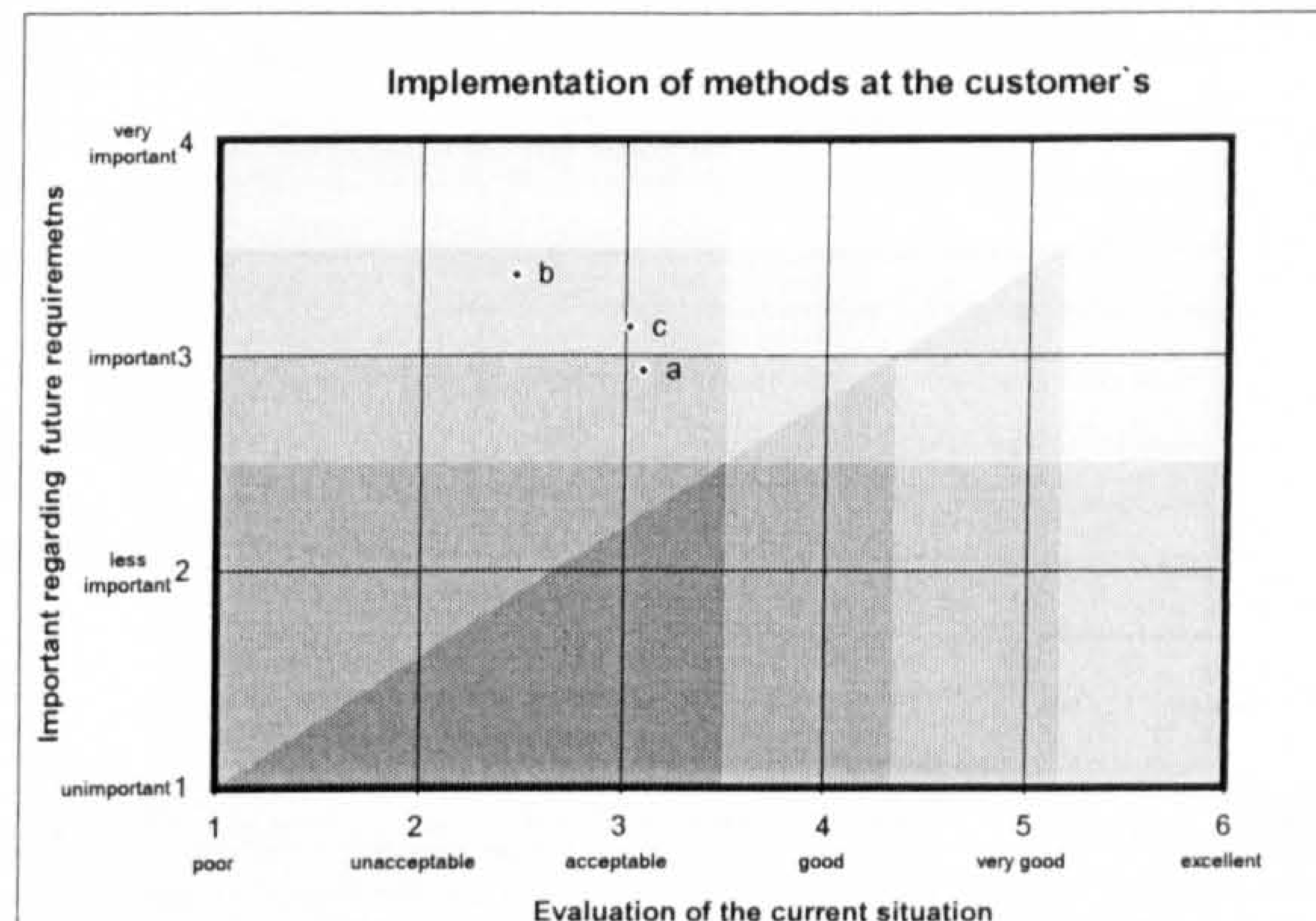
214 See Peters, J., The customer as a check for innovations, 1996, a conducted investigation came already 1995 to similar results, it can be speculated that, because of the awareness of the existing problems nothing happened since that time.

215 See investigated results regarding an earlier and more intensive integration of the supplier into the development process, chapter five, and Wilson, C./Gemini, C., Lean design in the automotive supply chain through integration, conference paper, 1997, p. 220

Based on an approach designed to optimise the overall system, where each partner is willing to make compromises, earlier integration of all development partners could help to improve interface definition (e.g. by joint workshops, resident engineers etc.)

8.4.2 Evaluation of the use of process methods by the customer

In addition to being asked about the relationship to the customer, participants were also asked about the internal situation at the customer. The question aimed to establish to what extent the customer used methods such as simultaneous engineering (a), quick and short decision-making processes (b) and collaborative teamwork (Figure 8.20).



Index	Evaluation of the implementation of following elements at the customer`s.	evaluation	standart deviation	importance	standart deviation
a -	Simultaneous engineering	3.09	1.11	2.93	0.68
b -	Fast and short decision making process	2.47	1.22	3.38	0.70
c -	Intercooperational teamwork	3.03	1.31	3.13	0.72

Figure 8.20: Methods at the customer`s

The results show that according to suppliers, quick and short decision-making processes in particular, which are considered one of the main factors for reducing development time[216], are in need of improvement. The reason for this could of course be the fact that manufacturers' organisational units are generally larger than those of suppliers[217].

The other two aspects - simultaneous engineering and co-operational teamwork - also offer further potential for improvement.

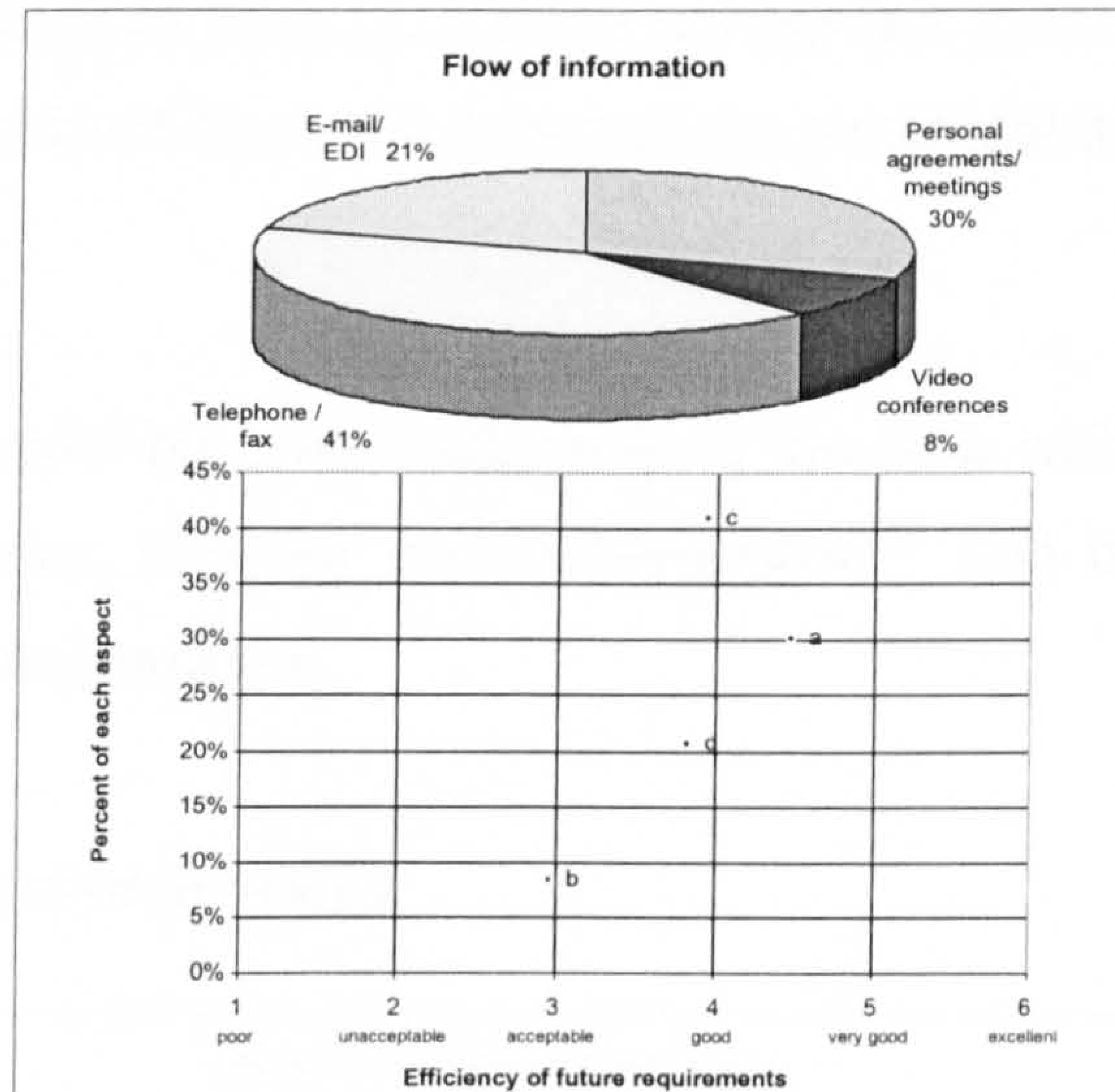
8.4.3 Evaluation of information flow and information management

Against a background of increasing globalisation, efficient information flow is continually gaining in importance[218]. As customers and suppliers are rarely on the same premises, means of communication must bridge the gap between the

[216] See Macbeth, D.K./ Ferguson, N., Partnership sourcing: An integrated supply chain management approach, 194, pp. 67 ff./119 ff. ; and, Tushman, M.L./ O`Reilly, C.A., Winning through innovation, 1997, pp. 142 ff.
[217] See Plönzke, K.C., Führen in Netzwerken – Der Manager als Dienstleister, in: Fuchs, J. (editor), Das Biokybernetische Modell, Wiesbaden 1996, pp. 157-158
[218] See Evans, G.N./Naim, M.M./ Towill, D.R., Dynamic supply chain performance: Assessing the impact of information systems, in: Logistic Information Management, Vol. 6, No. 4, 1993; and, Vroom, R.W., A general example model for automotive suppliers of the development process and its related information, in: Computers in Industry, No. 31, 1996, pp. 255-280

development teams involved. The flow of information to the customer and suppliers can take place in a number of ways (see Figure 8.21).

Survey participants gave the efficiency of personal meetings by far the highest ranking. Telephone and fax are currently the most frequently used means of communication (41%), followed by personal agreements/ meetings (30%), E-mail/EDI (21%) and video conferences (just 8%). The efficiency of video conferences is not rated very highly at present. This may be due to the fact that not all customers and suppliers have access to this facility yet. As this medium becomes more widespread (in-house and externally), similar to the development of E-mail and EDI in recent years, it will help to improve the efficiency of information flow.



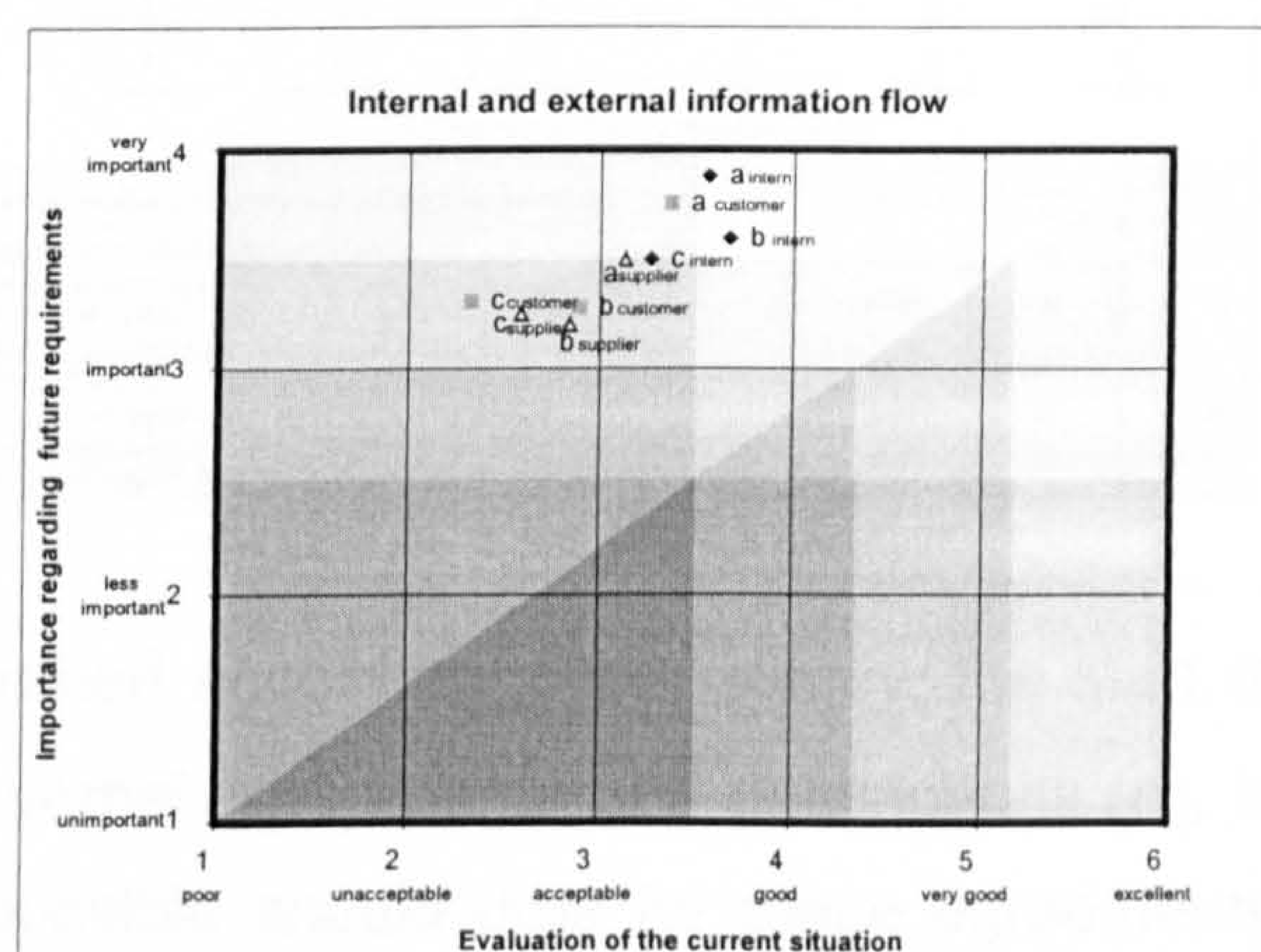
Index	Evaluation of how the information exchange between the customer and the supplier is currently handled.	%	efficiency	standart deviation
a -	Personal agreements/meetings	30	4.47	1.12
b -	Video conferences	8	2.69	1.27
c -	Telophone/fax	41	3.93	0.81
d -	E-mail/EDI (electronic data interchange)	21	3.82	1.31

Figure 8.21: Flow of information between the customer and the supplier

Internal and external information flow:

A more detailed analysis of the current efficiency and significance of internal and external data and information flow produced the following result (see Figure 8.22).

The figure shows that nearly all those questioned rated general internal and external information flow ($a_{internal,\ customer,\ supplier}$) as a top priority. This shows just how important this question is. Despite an overwhelmingly positive reaction, an evaluation of the current status reveals that there is still a need for further action. The internal data network ($b_{internal}$) received the highest overall ranking. If this assessment is taken as



Index	Evaluation ot general/specific situations inside the projets regarding...	evaluation	standard deviation	importance	standard deviation
a_{intern} -	internal information flow (in general).	3.56	0.93	3.88	0.33
b_{intern} -	internal data network.	3.67	1.06	3.59	,0.56
c_{intern} -	system compatibility between locations/dept., e.g. CAx.	3.26	1.22	3.50	0.66
$a_{customer}$ -	external information flow to the customer (in general).	3.36	0.92	3.75	0.50
$b_{customer}$ -	external data network to the customer.	2.88	0.93	3.27	0.66
$c_{customer}$ -	system compatibility to the customer, e.g. CAx.	2.32	0.90	3.30	0.76
$a_{supplier}$ -	external information flow to the supplier (in general).	3.13	1.04	3.50	0.62
$b_{supplier}$ -	external data network to the supplier.	2.84	1.00	3.20	0.75
$c_{supplier}$ -	system compatibility to the supplier, e.g. CAx.	2.59	1.03	3.25	9.74

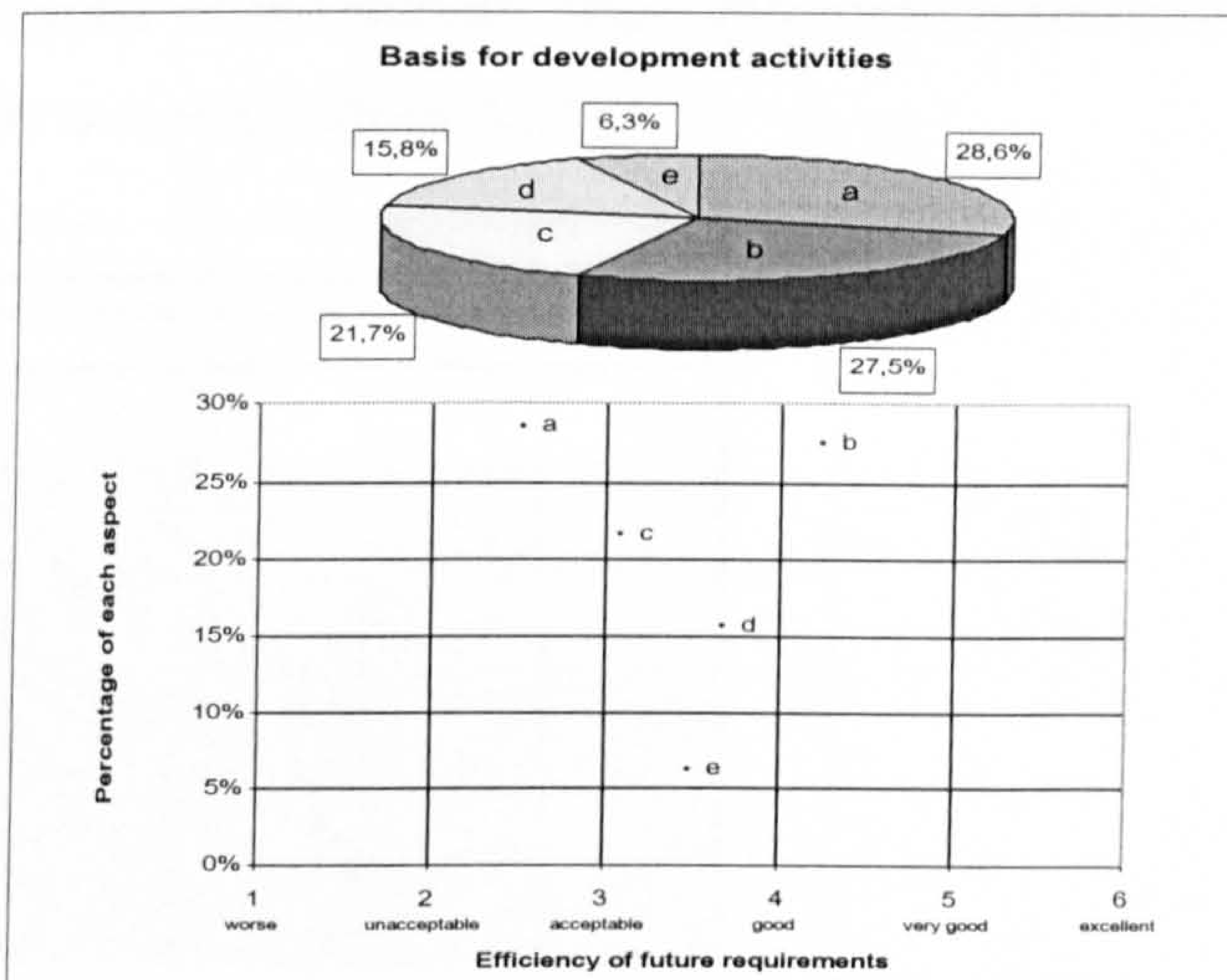
Figure 8.22: Internal and external information flow

a basis, it is possible to deduce the time and money which would have to be invested in external customer and supplier networking ($b_{customer, supplier}$) in order to achieve the same high performance as for the internal network.
As far as the compatibility of system resources ($c_{internal, customer, supplier}$) is concerned, there is a considerable need for action. Efforts should be made internally to avoid isolated solutions where possible.

Before the start of a project, thought should be given externally to the data which have to be exchanged between customer, supplier and sub-supplier[219] and the data formats which should be used for this purpose.

8.4.4 Evaluation of the basis for development activities

One of the key problems encountered in the field of development concerns the clarification of product requirements. The question was aimed at finding out which of the given possibilities are used and how efficient each of them is (see Figure 8.23).
Specifications provided by the customer in the form of a detailed technical and functional description (b) have proven to be the most efficient means to



Index	Development activities starts on the basis of....	efficiency	standard deviation	% of use
a -	verbal agreements/descprition.	2.52	1.13	28.6
b -	design specification in form of a detailed technical and functional description.	4.24	1.24	27.5
c -	design specification in form of an abstract functional description.	3.08	1.00	21.7
d -	workshops together with OEM's specialists.	3.67	1.49	15.8
e -	workshops togehter with OEM's specialists and the most important development partners/sub-suppliers.	3.48	1.56	6.3

Figure 8.23: A basis for development

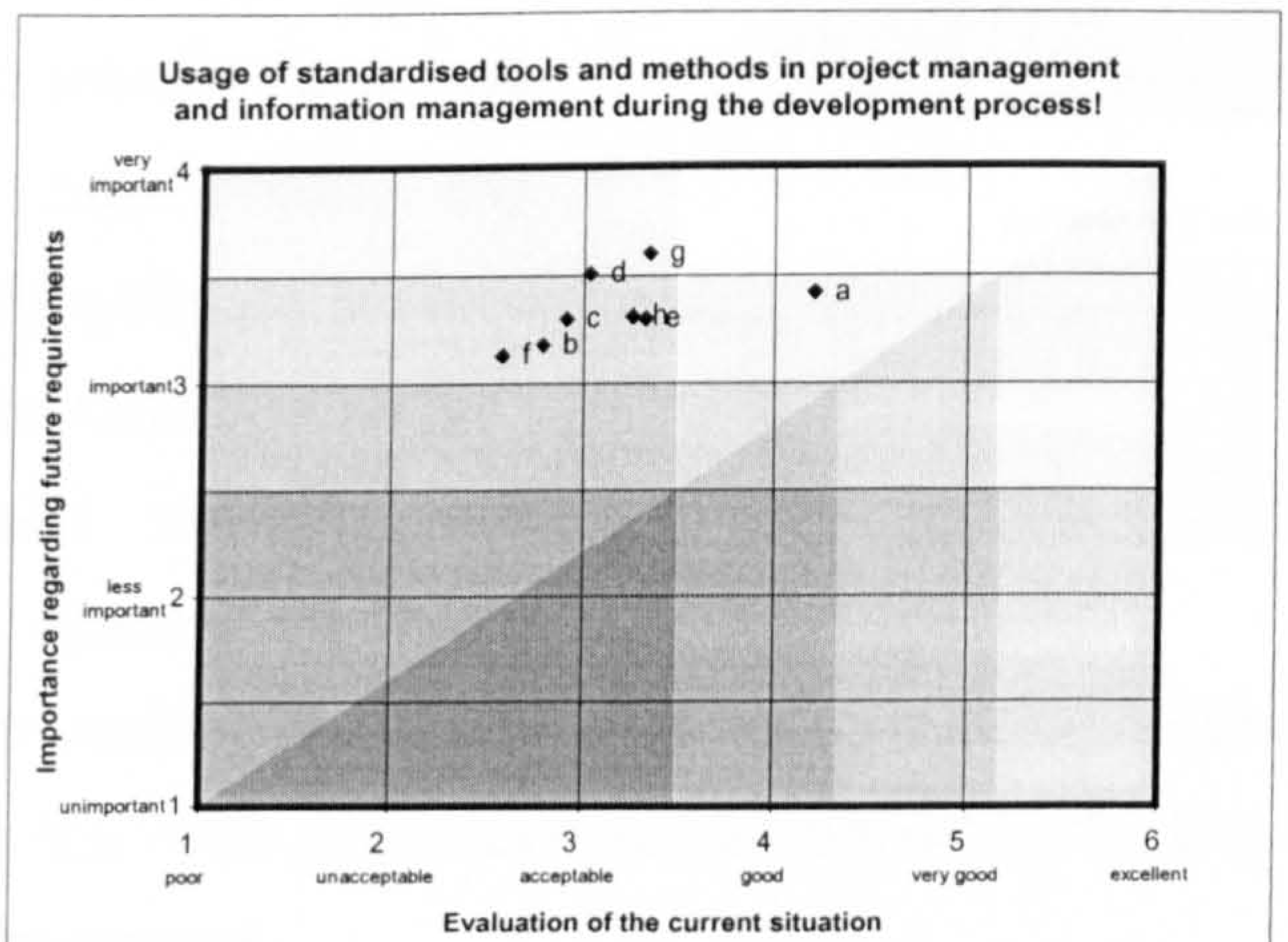
date. The most frequently practised method according to the survey, the start of development activities on the basis of verbal agreements and descriptions (a), is considered very inefficient. Those responsible should urge for these agreements to be more binding and, if possible, for product requirements to be specified jointly in writing.

The efficiency of workshops at which the main peripheral conditions are decided between manufacturer and sub-suppliers quickly and without major iteration was rated relatively highly. The reason why few workshops of this kind are held at the moment could be due to the fact that they are still thought to require too much time and money to co-ordinate and that the early and comprehensive exchange of information is not considered desirable.

In order to achieve the greatest possible mutual benefit, with exact, binding product specifications being fixed as early as possible, workshops would be a good way of replacing inefficient processes such as development starts as a result of verbal agreements or abstract specifications.

8.4.5 Evaluation of tools and methods

Methodical procedures and tools can help to improve the efficiency of product development processes[220]. The results of the survey show the importance which participants in general attach to this subject (Figure 8.24).



Index	Evaluation of the usage of standardised tools and methods in project management and information management during the development process.	evaluation current situ.	standard deviation	importance	standard deviation
a -	Reviews	4.21	0.99	3.42	0.70
b -	Resource planning tools	2.79	1.51	3.18	0.90
c -	Budget planning tools	2.91	1.34	3.30	0.76
d -	Cost control tools	3.03	1.34	3.52	0.74
e -	Schedule/milestone control tools	3.32	1.02	3.30	0.72
f -	Component reliability prognosis	2.58	1.26	3.13	0.79
g -	Design/process FMEA	3.35	1.16	3.61	0.60
h -	Technical calculation tools	3.26	1.39	3.31	0.70

Figure 8.24: Use of tools and methods

The current valuation of reviews (a) is extremely pleasing. This confirms the advantage of a methodical procedure in the product development process. Nonetheless, participants' comments reveal that the current system is still too

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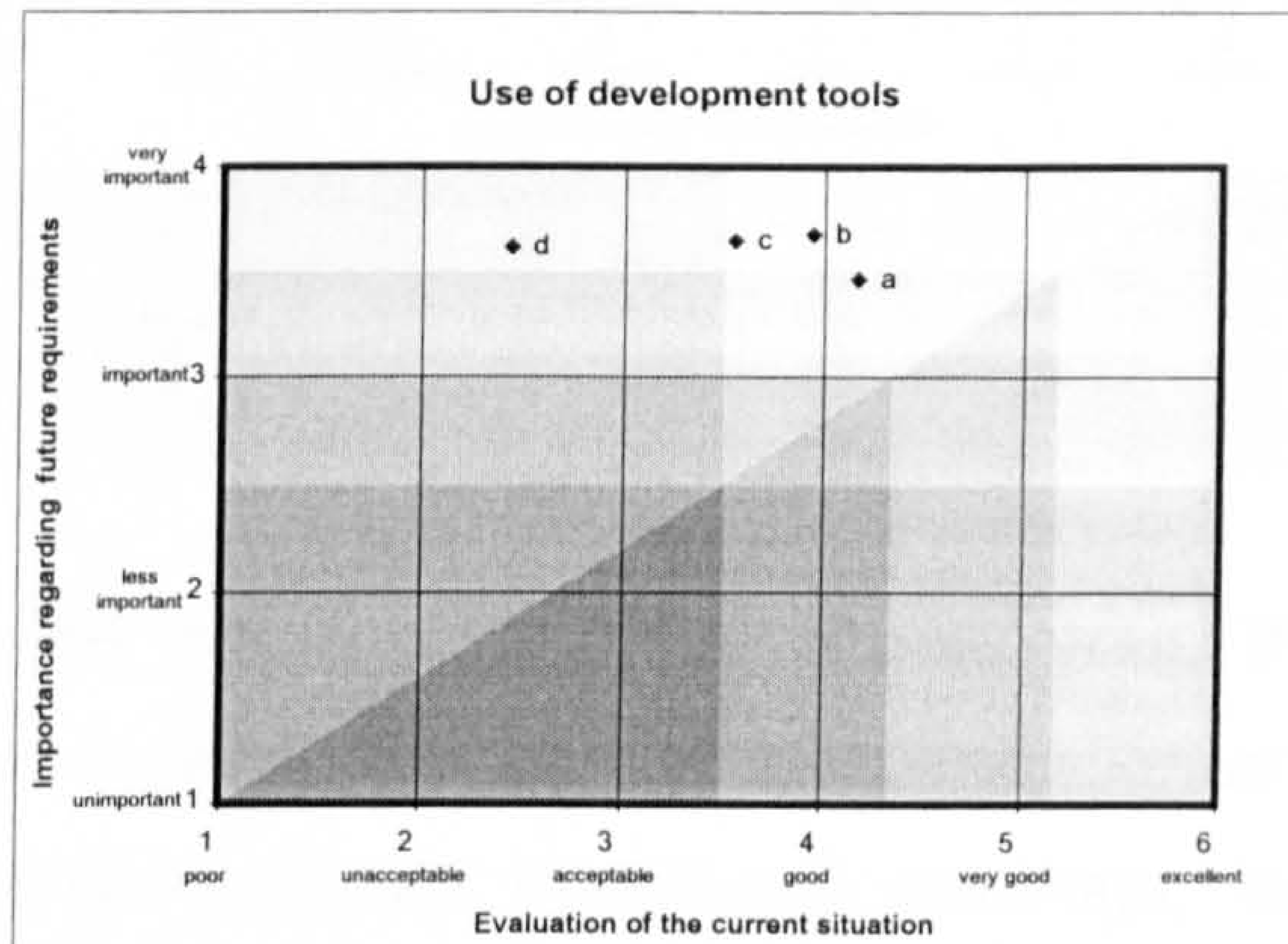
[219] See Vroom, R.W., What is the information that should be generated by the engineering departments of automotive supplier companies?, 1994, pp. 413-420

[220] See Scott, C./Westbrook, R., New strategic tools for supply chain management, in: International Journal of Physical Distribution & Logistic Management, Vol. 21, No. 1, 1991, pp. 23-33; Holst, J., Lean Development, 1995; and, Eversheim, W. (editor), Prozeßorientierte Unternehmensorganisation, 1996

inflexible and in need of further improvement. The same applies to capacity planning (b), budget planning (c), cost monitoring (d) and milestone and progress monitoring tools (e) whose biggest disadvantage is that they are sometimes too complicated to use and cannot be adapted sufficiently to specific conditions.
More flexible tools could lead to improvements. This should be investigated in the course of a special situation and market analysis. The same applies to component reliability forecast tools (f) and technical calculation tools (h) which must be made more efficient as product complexity increases.

The field of design and development tools (Figure 8.25), which are essentially the basic tools of development areas, is rated as very important. With the exception of the development tool for functions (e), the efficiency of current development tools for mechanical components (a), hardware (b) and software (c) is rated as good. Since these tools are subject to relatively frequent updates and system extensions, special emphasis should be placed on making sure that staff receive comprehensive training and further instruction. In the case of function development tools, there is still plenty of scope for future improvement.



Index	Evaluation of the usage of tools for...	evaluation	standard deviation	importance	standard deviation
a -	mechanical parts.	4.17	1.07	3.46	0.63
b -	hardware.	3.94	1.16	3.68	0.54
c -	software.	3.55	1.16	3.65	0.55
d -	functions.	2.44	1.20	3.66	0.63

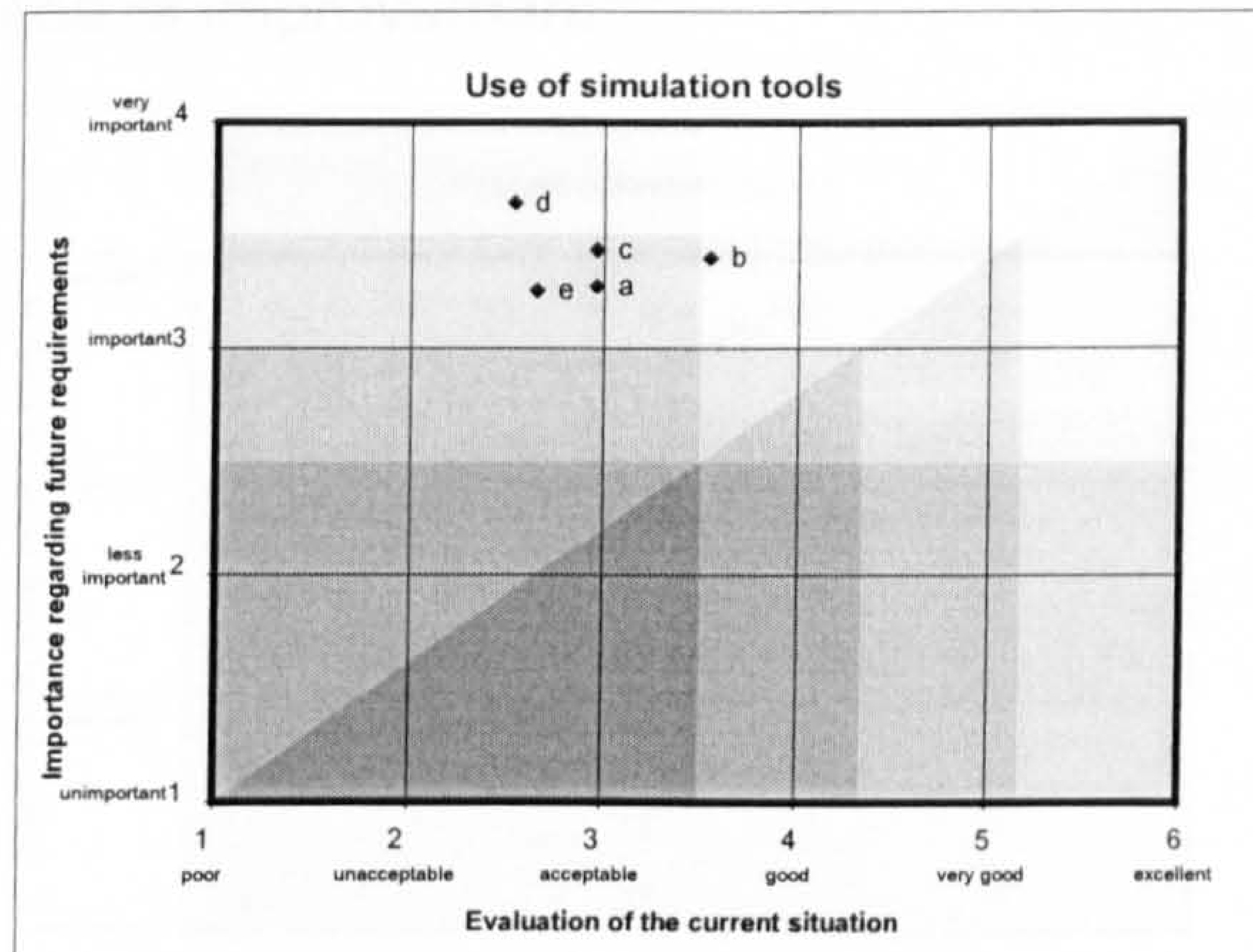
Figure 8.25: Development tools

The field of simulation tools is particularly important for shorter development times. These tools can be used to minimise costly test and pilot runs which ultimately lead to savings in time and costs. The time saved could be used, for example, for further product optimisation or for other projects. In this way, especially in early concept phases, the feasibility of later product functions can be tested and later product behaviour simulated in operating conditions.

This is particularly important for product integration. While several pilot phases have to be carried out otherwise to establish the final product configuration, the parameters obtained from simulations can be used to define the configuration of the product.

According to the results of the survey (Figure 8.26), simulation tools have top priority for the reproduction of functions (d). The current status for these tools is rated as insufficient.

The results for hardware simulation tools (b) do, however, provide a ray of hope. Due to increasing complexity and variant diversity, the subject of simplified access to project-specific and general information - databases and virtual libraries - is of particular importance. Although results indicated the future importance of this area, the current situation leaves something to be desired. The central administration and systematic archiving of already qualified components, introduced drawings, test results etc., could thus help to save a great deal of time.



Index	Evaluation of the usage of simulation tools for...	evaluation	standard deviation	importance	standard deviation
a -	mechanical parts.	2.96	1.35	3.27	0.52
b -	hardware.	3.55	1.41	3.39	0.62
c -	software.	2.96	1.34	3.43	0.65
d -	functions.	2.54	1.22	3.64	0.64
e -	environmental tests.	2.65	1.62	3.25	0.72

Figure 8.26: Use of simulation tools

8.4.6 Evaluation of the internal development process

Alongside project management, internal development organisation - the project team - is the other main component in the process-oriented development process. It is therefore rated as the most important factor. The results of the survey provide impressive confirmation of this (see Figure 8.27).

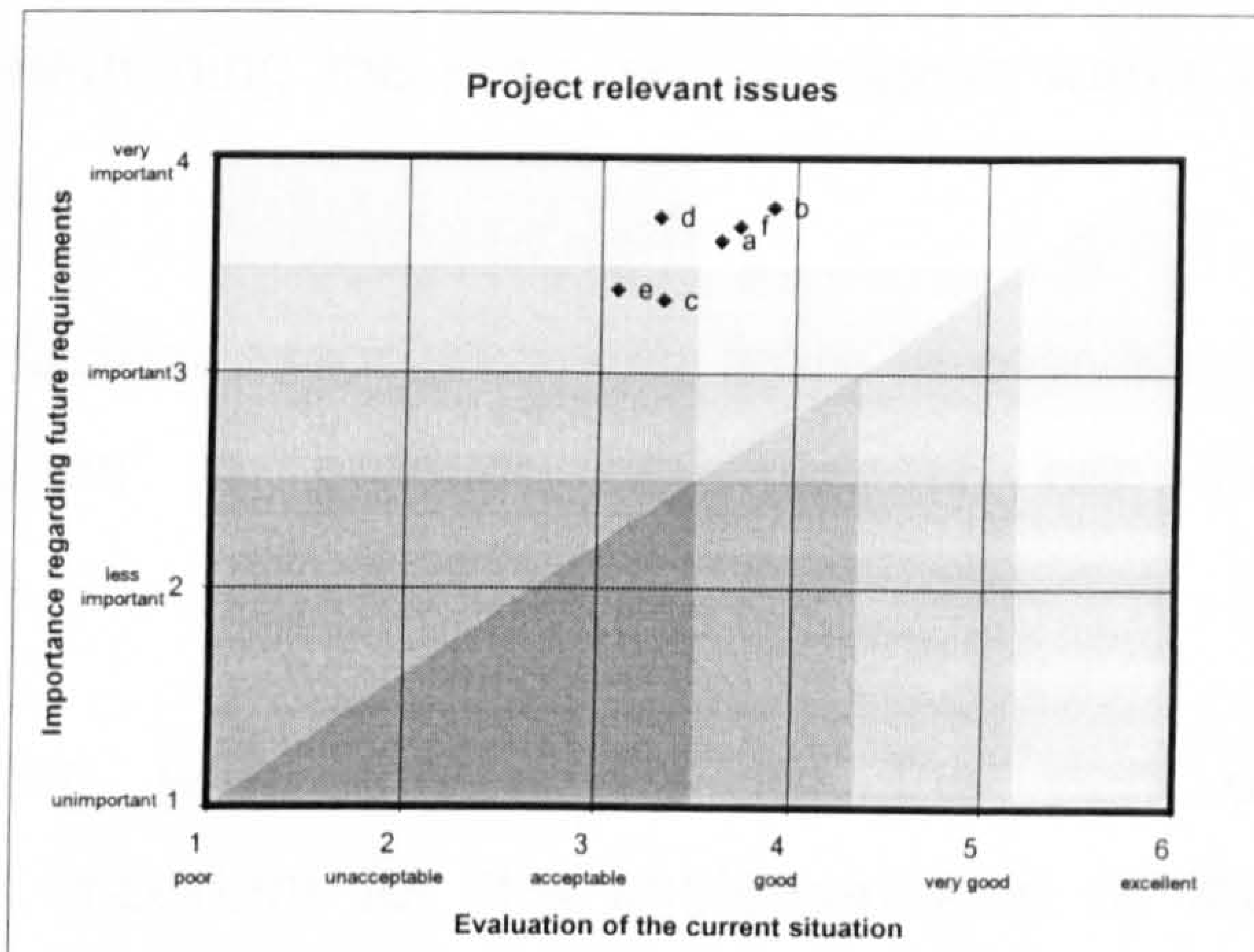
The shifting of responsibility and decision-making powers to the project manager is considered one of the most important prerequisites for quick and short decision-making processes in the project[221]. The survey results therefore also give top priority to the decision-making authority of the project manager (a).

Despite a basically positive valuation, comments reveal that project managers currently do not yet enjoy the right balance between responsibility and authority.

[221] See Fujimoto, T., Organisation for effective product development, 1989, pp. 455 - 456

The line-up of the project team (b) and interdisciplinary co-operation between team members (f) are rated positively. According to the participants, the lack of resources and team spirit are most in need of improvement[222].

Special importance should be attached to the geographic situation (spread over several sites) of team members (e). With regard to integrating Purchasing at an earlier stage (c), project managers believe there is potential for improvement, especially in terms of greater deadline and project orientation on the part of Purchasing. The integration of key development partners - sub-suppliers - into the project team (d) also reveals scope for improvement.

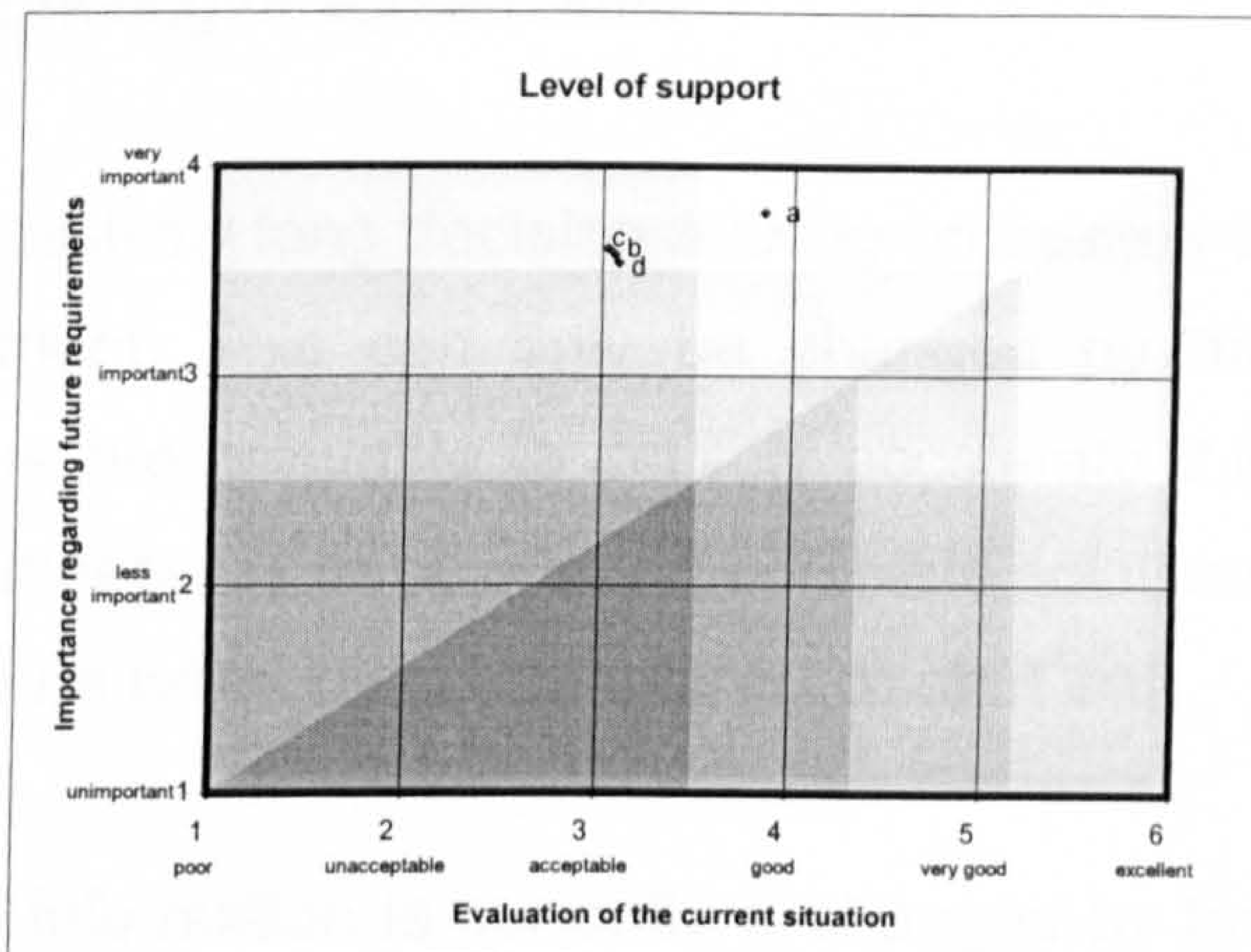


Index	Evaluation of following project related issues:	evaluation	standard deviation	importance	standard deviation
a -	Authority of the project leader	3.62	1.26	3.61	0.49
b -	Composition of the project team (in general)	3.88	1.21	3.76	0.42
c -	Early involvement of the purchasing department	3.32	0.99	3.33	0.59
d -	Integration of important development partners	3.30	1.14	3.72	0.45
e -	Localisation of all team members	3.09	1.01	3.38	0.59
f -	Interdisciplinary collaboration of all team members	3.71	0.79	3.68	0.47

Figure 8.27: Project relevant issues

This is expressed in the insufficient use of support by suppliers (c, b, d), as shown in Figure 8.28. As product complexity increases, it will become increasingly necessary to include internal and external suppliers in the project team.

Another interesting aspect is the fact that project managers consider their own company's customer support (a) to be better than the support provided by suppliers. It is essential to eliminate this discrepancy.



Index	Evaluation of support activities concerning following facts:	evaluation	standard deviation	importance	standard deviation
a -	Support to the customer e.g. resident engineer	3.84	1.50	3.77	0.42
b -	Support from the supplier regarding concept definition	3.06	0.95	3.57	0.56
c -	Support from the supplier regarding technology issues	3.03	0.80	3.60	0.55
d -	Support from the supplier regarding qualification issues	3.10	0.96	3.53	0.67

Figure 8.28: Level of support - to the OEMs, from the suppliers -

[222] See Eversheim, W., Prozeßorientierte Unternehmensorganisation, 1996, p. 120

8.5 Summary

In conclusion, the following statements showing where the trend is going can be derived from the analyses described in the foregoing. They can serve as an additional indicator for suppliers in determining the path their business wants to follow in terms of structure and strategy.

Based on the investigation, the main factors associated with more intensive and efficient customer-supplier co-operation in product development can be summarised as follows:

- Meeting deadlines and complying with agreements on the part of manufacturers is considered very important for the implementation of the challenging demands of the future. The current situation can, however, be described as poor. There is considerable potential for making improvements by saving time and money.

- The situation is much the same for sub-suppliers. Major potential for an improved development process is lost as a result of the inability to meet deadlines, the lack of trust and the ignoring of agreements.

- The supplier also considers the excessively long decision-making processes at OEMs' to be in need of improvement. This can only be changed by the manufacturers themselves. Suppliers are only able to actively accelerate this process with the help of supporting measures or by offering complete solutions to reduce the number of decisions to be taken by manufacturers to start with.

- Despite the fact that the majority of information is currently exchanged by fax and telephone, personal arrangements and meetings were considered to be more efficient with regard to future requirements.
  This is especially important in the initial phase of the development process when a more precise and comprehensive exchange of information provides the basis for a successful and efficient development process. The results show that developments are most frequently started on the basis of detailed descriptions of specifications and that this method is considered very efficient. Closer and more personal co-ordination on the basis of joint workshops during the

quotation phase, for example, is seen as an efficient and purposeful alternative, especially with regard to reducing later cost-intensive and time-consuming changes. Development starts on the basis of verbal agreements was considered the worst, but also the most frequent, method.

- The importance of information flow, to manufacturers on the one hand and to sub-suppliers on the other, was considered to be of the utmost importance. However, the fact that networking does not sufficiently include manufacturers and sub-suppliers and poor system compatibility make far-reaching improvements necessary. A detailed status review would be appropriate here in order to analyse and eliminate possible weaknesses.
  The aim should therefore be to ensure an efficient and comprehensive flow of information and a structured process, especially in the initial phase when the course is set for later cost and time input.

- Standard and development tools/methods were considered very important. While the use of individual special applications (Section 7.4.4.5) still has potential for improvement, the complexity and inflexibility of some tools/methods was seen as a shortcoming.
  In view of increasing product complexity/integration and decreasing development times, tools and methods must be designed to ensure quick, simple and flexible usage.

- As far as the analysis of internal project organisation - project team - is concerned, the following points must be observed in order to fulfil the conditions for an optimum process-oriented development process:
  - Project managers must have the necessary authority in order to ensure short decision-making processes. The survey found this area to be in need of improvement.
  - Integration of important development partners at the earliest possible stage (internal and external). One important point to note here is that the company considered its own customer support to be much better than the support provided by sub-suppliers. Sub-suppliers can and must be reminded of their duties and take on additional tasks. Correct project team line-up (number, powers).

- Central project team location in order to ensure a quick exchange of information and short decision-making processes.

Chapter Nine: Answers to the defined questions

9.1 An optimised organisational model for automobile suppliers with respect to the requirements for the individual supplier levels and general changes in the OEM-supplier relationship.

At this point, the reader should have a solid understanding of the trend of product integration and the corresponding changes in the OEM-supplier relationship. The previous chapters presented a clear picture of the trend toward system standardisation, the expected requirements of each individual supplier level, the general changes in the relationship between the OEMs and the supplier. This chapter aims to provide an optimised organisational model for automotive suppliers based on the relevant facts that have been investigated, analysed and presented in the foregoing (Figure 9.1).

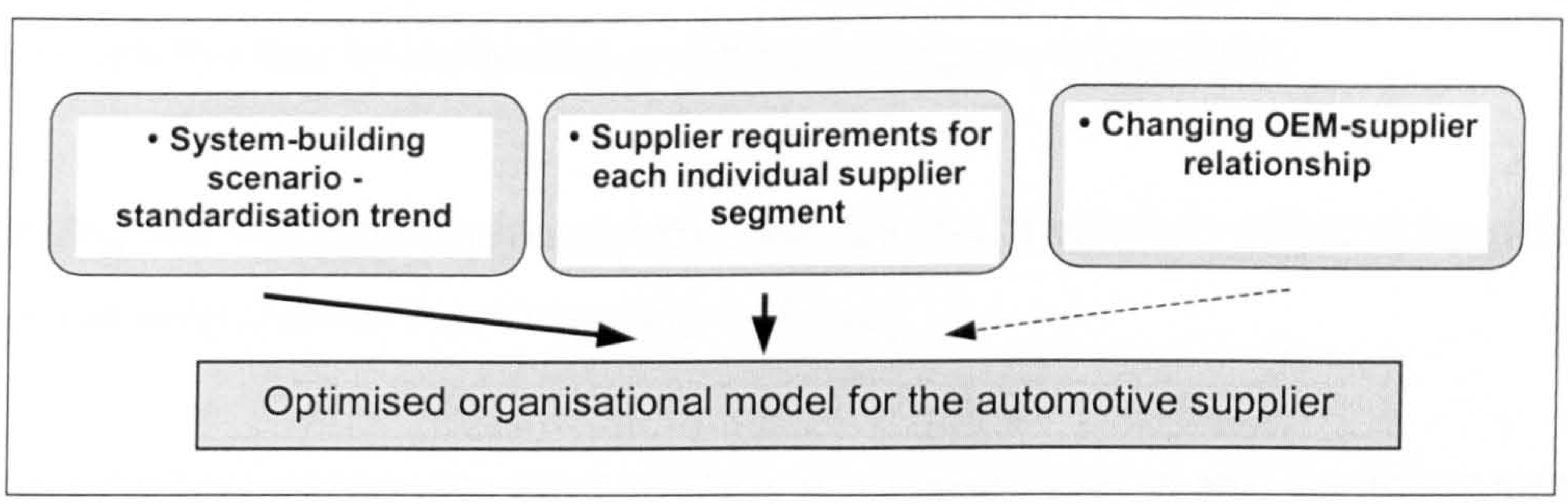


Figure 9.1: Factors involved in the development of an optimised organisational model for automotive suppliers

General remarks on the organisational model with applicability to all supplier levels (system, sub-system, component):

No major tendency toward standardisation of system building - product segmentation scenario - (Chapter Six) was found. Every automobile manufacturer does its own thing. Whereas, one OEM may treat a specific unit as a system due to contents, supplier relationship, complexity and strategic importance, another OEM may still treat it as a component.

This fact leads to a situation where the supplier has to guarantee a maximum of flexibility and have a relatively flexible organisation in order to meet various requirements in accordance with different systems of classification.

This might be achieved by:

- One of the most important points, the simplification and unbureaucratic adjustment of the dedicated resources among the projects within one level and among the supplier levels and business units.

- Changing/adapting attitudes and moving away from thinking in terms of hierarchies and departments.

- Close identification with the company.
  Improve the use of the enormous potential of each member of staff in terms of experience and know-how by dedicating more responsibility and accountability to the people. They are the pillars of any organisation. They determine whether a company is successful or not, independently of the theoretical characteristics of organisational structures. Motivated, satisfied employees who enjoy their work are the key to achieving ambitious company objectives.

- Making the decision-making processes shorter and more efficient by giving the person responsible the necessary authority.

- Ensuring that necessary equipment is furnished, budget etc. for the appropriate organisational elements based on their business segment (system-, sub-system or component business), e.g. system supplier → installing appropriate R & D resources, ensuring high development capabilities and a high innovation rate in addition to ensuring global presence, etc.
  Component supplier → costs leader, fast reaction time, etc.
  Making sure that the individual organisational segments are capable of meeting the specific demands (Figure 9.2).

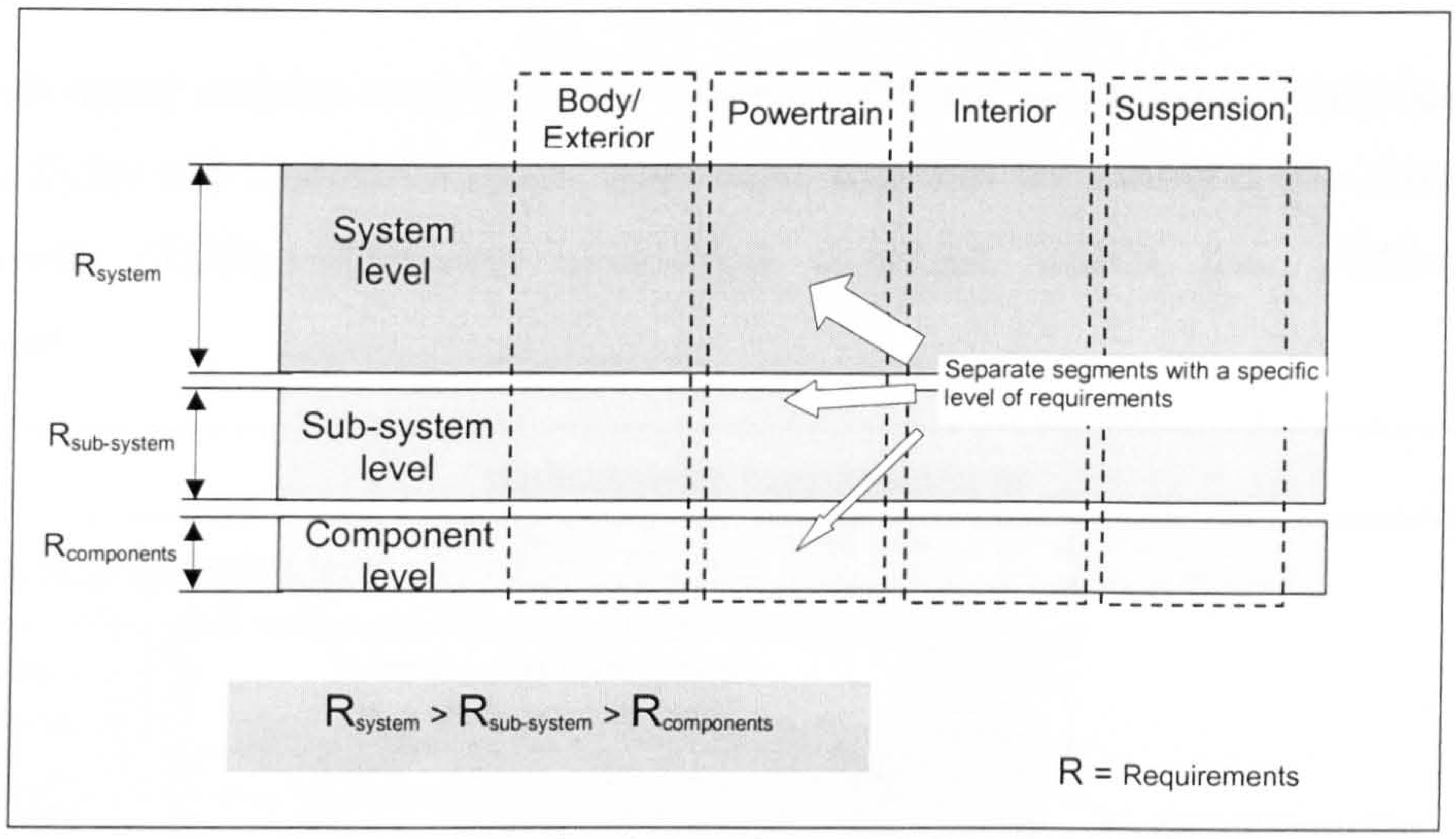


Figure 9.2 Grade of requirements for each individual supplier level

The circumstance that the pyramid-shaped structure of suppliers with the system suppliers being responsible for the co-ordination of the sub-system and the component supplier will not be implemented systematically further increases the need for a highly flexible organisation that can react within the amount of time available despite differing OEM behaviours.

The OEMs do still maintain contacts with sub-system suppliers and component suppliers, too, although the majority stated that “Intense and early involvement in the product development process is restricted to the system supplier. The system supplier is responsible for integrating the sub-system/component supplier into the development process”.

This may mean that the system supplier must bear a large portion of the project development risk while at the same time not being able to fully control the development process, information flow, product changes, etc.. This is due to the fact that the OEMs still maintain direct contacts with the sub-system supplier and component supplier.

Organisational model with a focus on the system supplier level:

The above-listed results were used to develop the following organisational model (Figure 9.3) for the system supplier level as a solution for meeting the challenging requirements (Table 9.1) and upcoming changes within the OEM-supplier relationship.

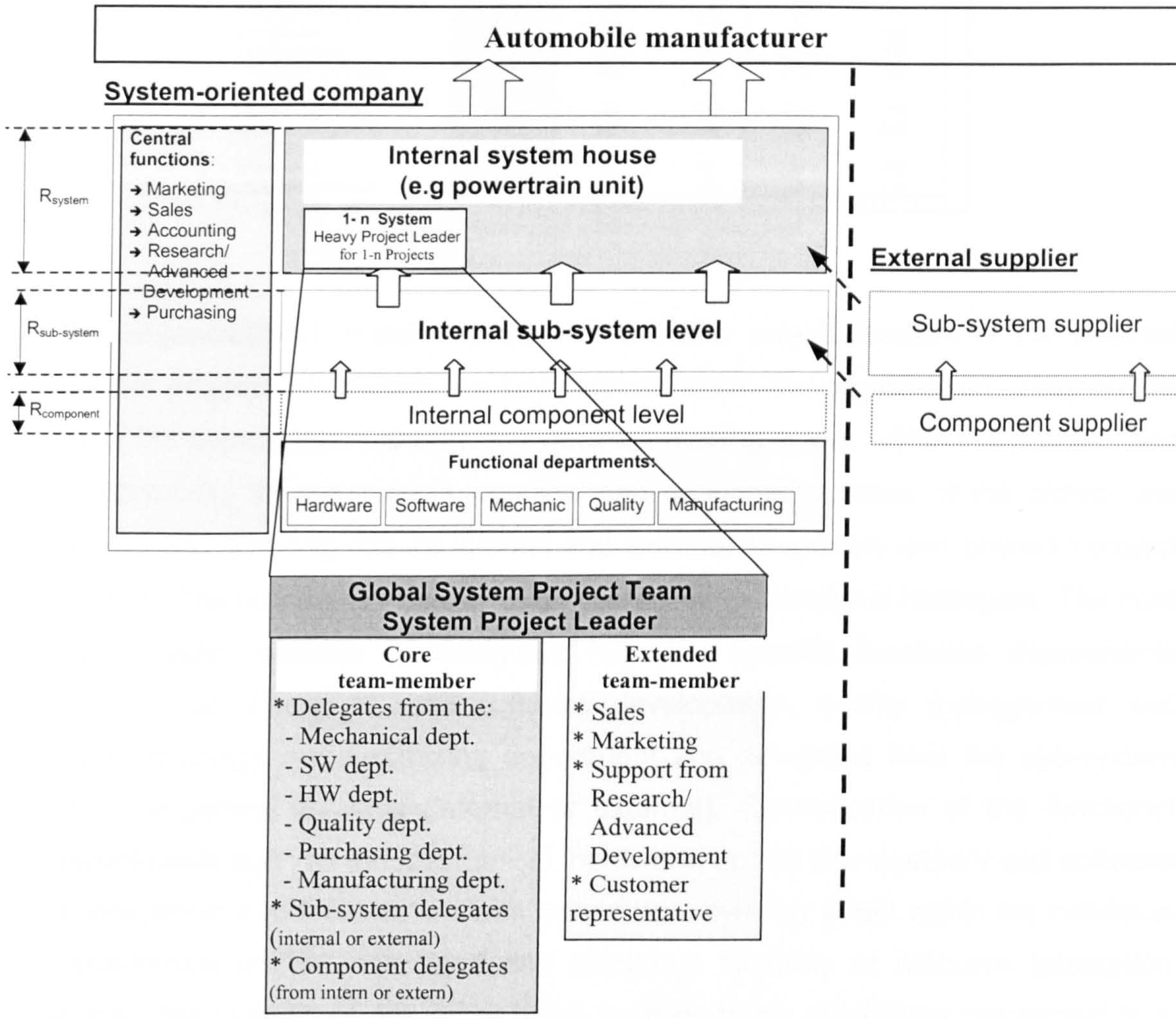


Figure 9.3: An alternative organisational structure with a focus on the system level

In view of the high ranking of requirements relating to "R & D resources", "innovation rate" and especially the "development capabilities", the system supplier (system level) must be suitably equipped with the appropriate tools, manpower and infrastructure. The level of required know-how in the mechanical, the electric/electronics, software and production fields also shows a high demand when applying a scale of 1 = low and 6 = high. The requirements for the system supplier are as much as 2.56 higher compared to the sub-system and component level with the exception of the point, "cost pressure", where the highest demands are at the component supplier level.

Comparison of the supplier requirement rankings (used scaling 1 to 6, 1=low, 6=high)

Topic	Ranking system supplier level	Comparison: system level to sub-system level		Comparison: system level to component level	
		Delta	Factor	Delta	Factor
R&D resources	5.71	0.85	1.17	2.28	1.66
Development capabilities	6.00	0.64	1,12	1.86	1.45
Innovation rate	5.83	0.5	1,09	1.66	1.40
Mechanical know-how	5.8	0.2	1.04	0.7	1.14
Electric/Electronic know-how	5.6	0.3	1.06	0.7	1.14
Software know-how	5.5	0.2	1.04	0.6	1.12
Production know-how	5.86	0.5	1.09	0.79	1.16
Quality management	5.87	0.22	1.04	0.22	1.04
Testing/qualification know-how	5.57	0.5	1.10	1.5	1.37
Reaction time	5.69	0.46	1.09	1.0	1.21
Logistic capability	6.00	0.86	1.17	2.79	1.87
Support by marketing new products/technologies	3.79	0.93	1.33	2.15	2.31
Global presence	5.86	1.0	1.21	2.15	1.58
Delegating manpower to the OEMs	5.75	2.17	1.61	3.5	2.56
Cost pressure	5.60	0	1.0	-0.1	0.98
Broad product spectrum	4.07	0.57	1.16	1.43	1.54

Table 9.1 Investigated requirements - system level

The organisational model is project-driven. The project leaders of the different system projects are among the key persons within the organisation. They should have the appropriate authority and decision-making power within the process and responsibility for the over-all technical and economic success of the project and should play a strong role as internal and external integrators and powerful project leaders. The ranking is relatively high compared to functional managers. The core project team consists of delegates from the specific functional departments (mechanical, hardware, and software development, quality management and manufacturing), the purchasing department and delegates from the sub-system and component divisions (internal or external). Centralisation of the functional departments such as the mechanical, hardware, quality management and software development departments ensures a maximum synergy effect within the individual departments on the one hand and maximum flexibility of resource adaptation among the projects on the other hand, independently of whether the project is a system, sub-system or component project.

The demanding requirements relating to “innovation” and “development capabilities” are addressed by having the extended team include specialists from the central sales and marketing department(s) and the research/advanced development department(s). A delegate from the customer guarantees optimised flow of and exchange of information.

The system supplier level (system house) must co-ordinate the development activities of the internal and external sub-systems and component suppliers.

The system house is the leading organ of the Inter Co-operational Supplier Structure (ICOSS).

The internal sub-system and component levels can also perform activities and carry out business directly with the OEMs, but only after having co-ordinated their activities with the system house in order to avoid conflict.

The internal sub-system and component divisions are treated as separate cost centres with reference to internal business with the system house and as profit centres with reference to external business.

The system house is set up as a profit centre and defines the target costing for the sub-system and component divisions.

Organisational model with a focus on the sub-system supplier:

The requirements for the sub-system level are not as stringent as they are for the system supplier level (Table 9.2). Therefore, equipment required by the sub-system level such as tools, manpower and infrastructure is not as extensive, which is especially important for companies who are only sub-system oriented.

Comparison of the supplier requirement rankings
(used scaling 1 to 6, 1=low, 6=high)

	Comparison: sub-system level to the system level		Ranking sub-system level	Comparison: sub-system level to the component level	
Topic	Delta	Factor		Delta	Factor
R&D resources	-0.85	0.85	4.86	1.43	1.42
Development capabilities	-0.64	0.89	5.36	1.22	1.29
Innovation rate	-0.5	0.91	5.33	1.16	1.28
Mechanical know-how	-0.2	0.97	5.6	0.5	1.10
Electric/Electronic know-how	-0.3	0.95	5.3	0.4	1.08
Software know-how	-0.2	0.96	5.3	0.4	1.08
Production know-how	-0.5	0.91	5.36	0.29	1.06
Quality management	-0.22	0.96	5.64	0.0	1.0
Testing/qualification know-how	-0.5	0.91	5.07	1.0	1.25
Reaction time	-0.46	0.92	5.23	0.54	1.12
Logistic capability	-0.86	0.86	5.14	1.93	1.60
Support by marketing new products/technologies	-0.93	0.75	2.86	1.22	1.74
Global presence	-1.0	0.83	4.86	1.15	1.31
Delegating manpower to the OEMs	-2.17	0.62	3.58	1.33	1.59
Cost pressure	0.0	1.0	5.6	-0.1	0.98
Broad product spectrum	-0.57	0.86	3.5	0.86	1.33

Table 9.2: Investigated requirements – sub-system level

The sub-system project teams are also less consistent. For instance, delegates from the research/advanced development and marketing departments are not in high demand.

Compared to the system level, the requirements are - with the exception of the point, "Cost pressure" - lower than the ranked sub-system requirements by up to 0.62 times (max delta = 2.17 using a scale from 1 = low to 6 = high). Requirements in the areas of "mechanical know-how", "software know-how" and "quality management" are more or less similar.

Requirements are higher by up to 1.6 times compared to the component level. By contrast, the differences in "product know-how" and "quality management" are marginal or even non-existent. This indicates that the focus is on "quality management", "mechanical know-how" and "production know-how" at the sub-system level. This would make research/advanced activities and marketing activities less crucial for sub-system oriented companies.

The organisation's structure is comparable to that of a system supplier. It is also project-driven with centrally organised functional departments and delegation of necessary manpower to the respective projects as needed. This structure guarantees a maximum of flexibility and synergy at the sub-system level. In a system-oriented company, business with the OEM is left to the system house. When conducting business with OEMs directly, the sub-system's activities must be co-ordinated with the system house and the project team is supplemented with a delegate from the central sales department. The sub-system business unit is also under pressure to act as a profit centre. Figure 9.4 shows the organisational model with a focus on the sub-system level.

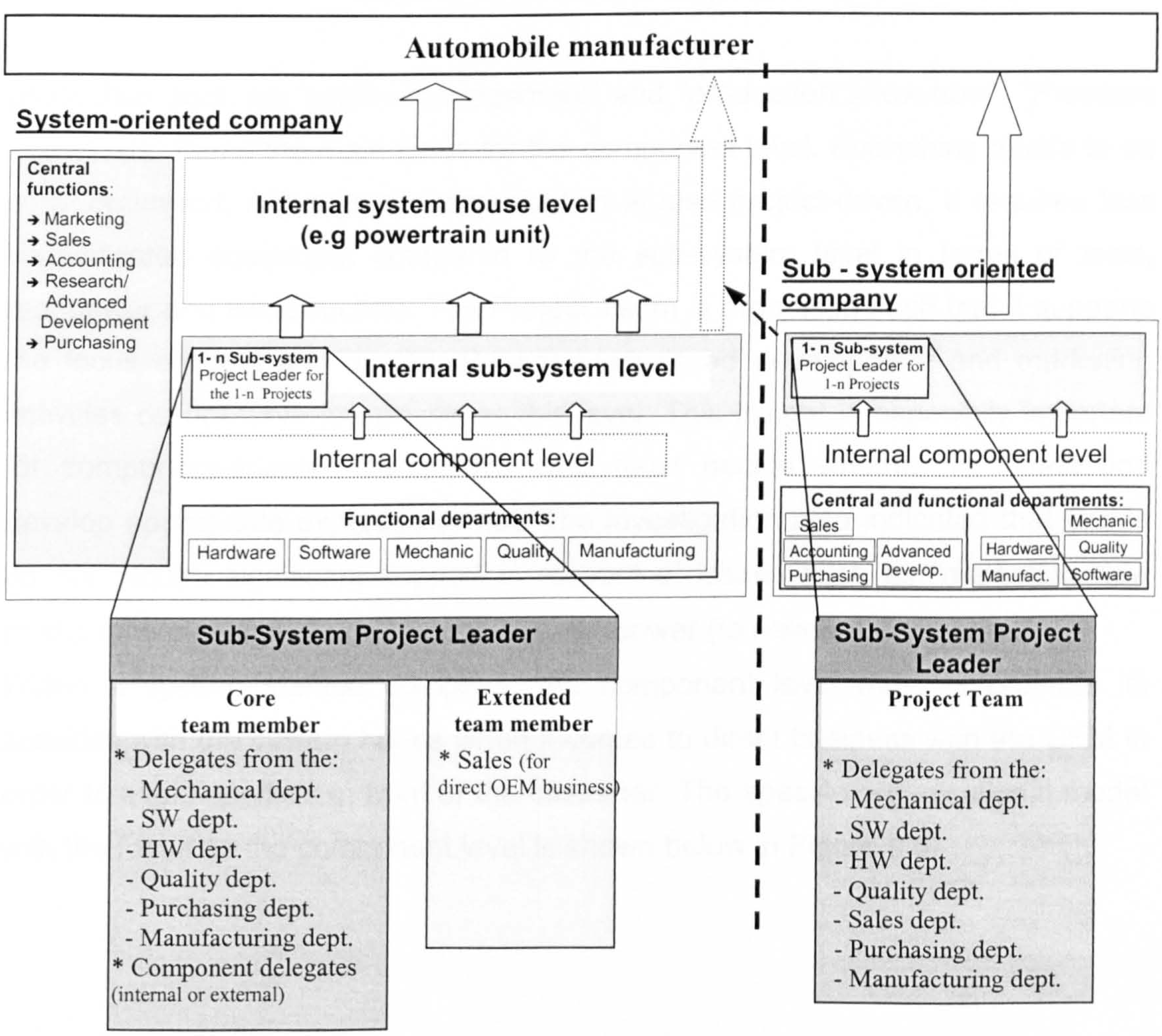


Figure 9.4: An alternative organisational structure with a focus on the sub-system level

Organisational model with a focus on the component supplier:

At the component level, it is evident that the decisive requirements are increasingly shifting from issues that are specific to R & D such as "innovation rate", "development capability", etc. to issues that are more strongly related to

Comparison of the supplier requirement rankings (used scaling 1 to 6, 1=low, 6=high)

Topic	Comparison: component level to the system level		Comparison: component level to the sub-system level		Ranking component level
	Delta	Factor	Delta	Factor	
R&D resources	-2.28	0.60	-1.43	0.71	3.43
Development capabilities	-1.86	0.69	-1.22	0.77	4.14
Innovation rate	-1.66	0.72	-1.16	0.78	4.17
Mechanical know-how	-0,7	0.88	-0.5	0.91	5.1
Electric/Electronic know-how	-0.7	0.88	-0.4	0.92	4.9
Software know-how	-0.6	0.89	-0.4	0.92	4.9
Production know-how	-0.79	0.87	-0.29	0.95	5.07
Quality management	-0.22	0.96	0.0	1.0	5.64
Testing/qualification know-how	-1.5	0.73	-1.0	0.80	4.07
Reaction time	-1.0	0.82	-0.54	0.90	4.69
Logistic capability	-2.79	0.54	-1.93	0.62	3.21
Support by marketing new products/technologies	-2.15	0.432	-1.22	0.57	1.64
Global presence	-2.15	0.63	-1.15	0.76	3.71
Delegating manpower to the OEMs	-3.5	0.39	-1.33	0.63	2.25
Cost pressure	0.1	1.02	0.1	1.02	5.7
Broad product spectrum	-1.43	0.65	-0.86	0.75	2.64

Table 9.3: Investigated requirements – component level

production such as "quality management" and "production know-how". "Pressure from costs" forms the main focus for the component level. Everything needs to be cost- optimised. Although the organisation is also project-driven, it requires less sophisticated equipment compared to the sub-system level in terms of tools, manpower and infrastructure. The Project Team is organised such that it supports the focus on cost and quality. Research/advanced development and marketing activities do not have top priority at this level. This insight is especially important for component-oriented companies who must decide whether to invest and develop appropriate expertise or not. The investigation also indicated that OEMs do not require significant support in respect of issues such as "marketing new products/technologies" and "delegating manpower (to resident engineers)".

Within a system-oriented company, the component level must co-ordinate its activities with the system house when it comes to direct business with the OEM in order to avoid conflicts in front of the customer. The specific organisational model with the focus on the component level is shown below in Figure 9.5.

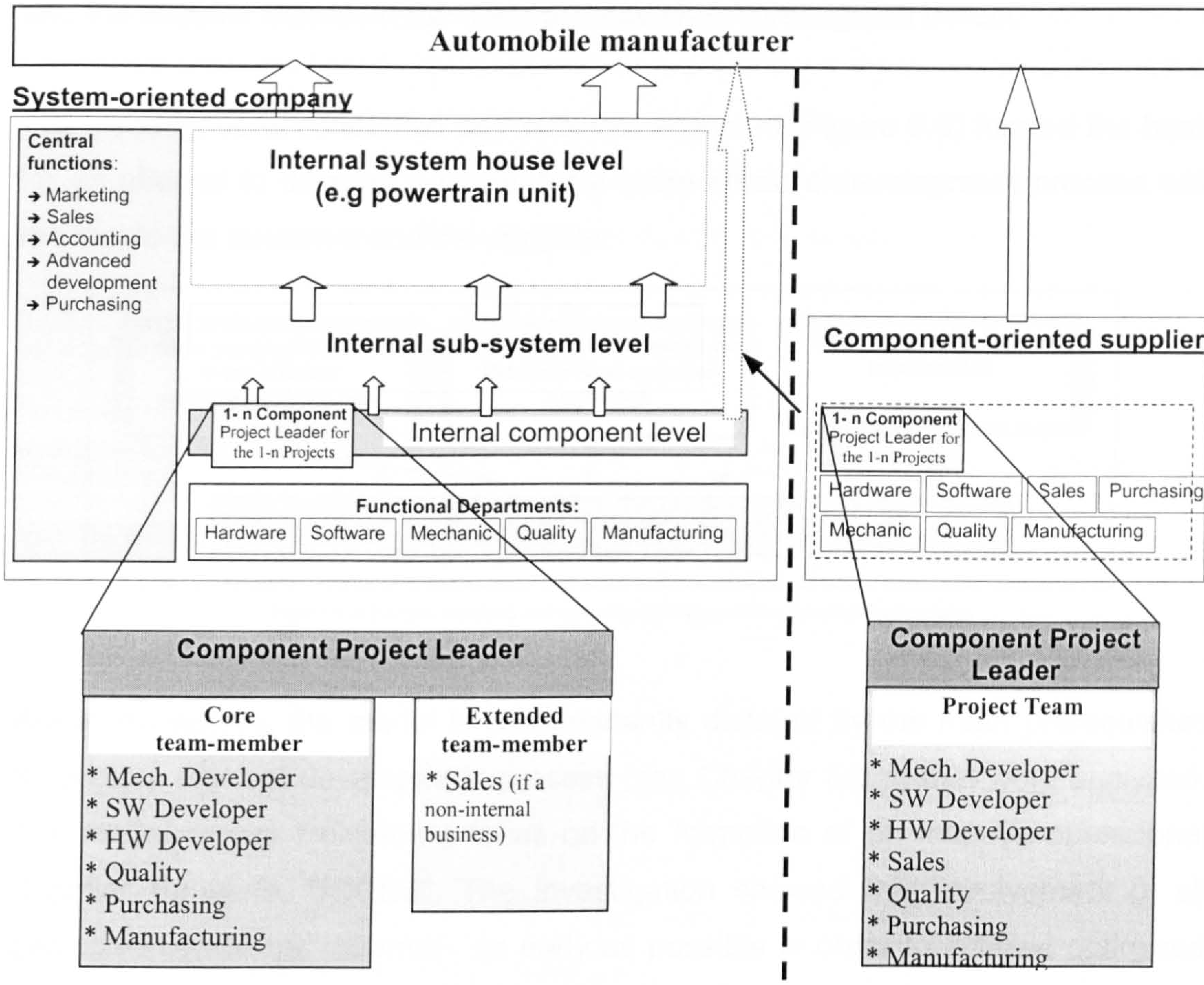


Figure 9.5: An alternative organisational structure with a focus on the component level

9.2 Model for more efficient co-operation in development between the customer and the supplier based on the main prerequisites investigated herein.

The investigations conducted and subjects analysed (Figure 9.6) formed the basis for an attempt to develop a model for a more efficient development process with respect to the customer and the supplier.

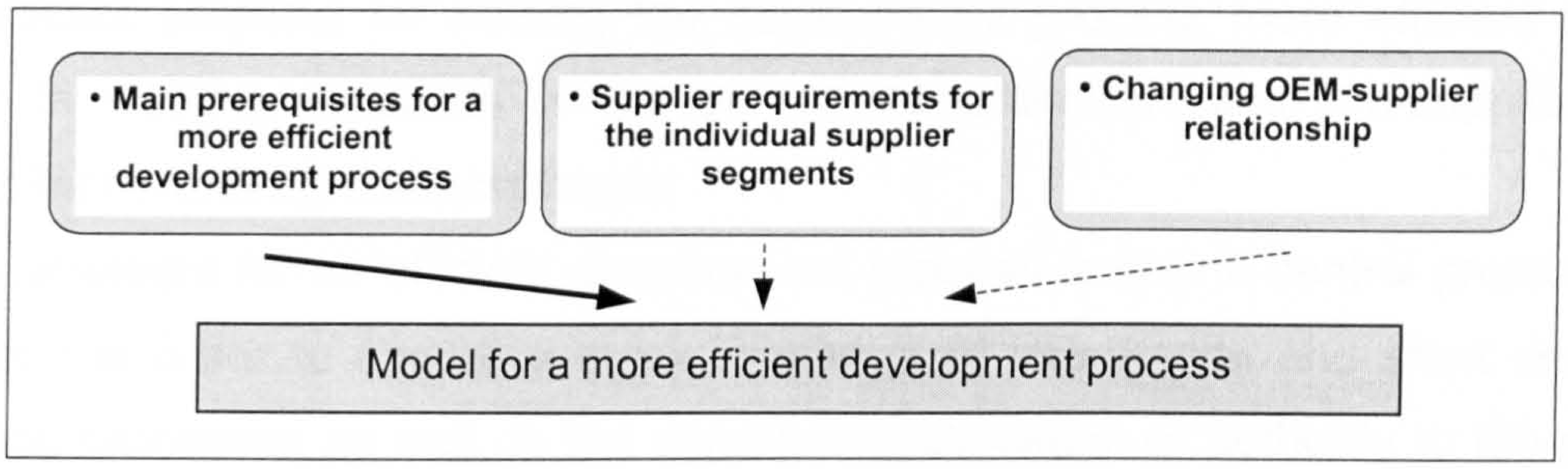


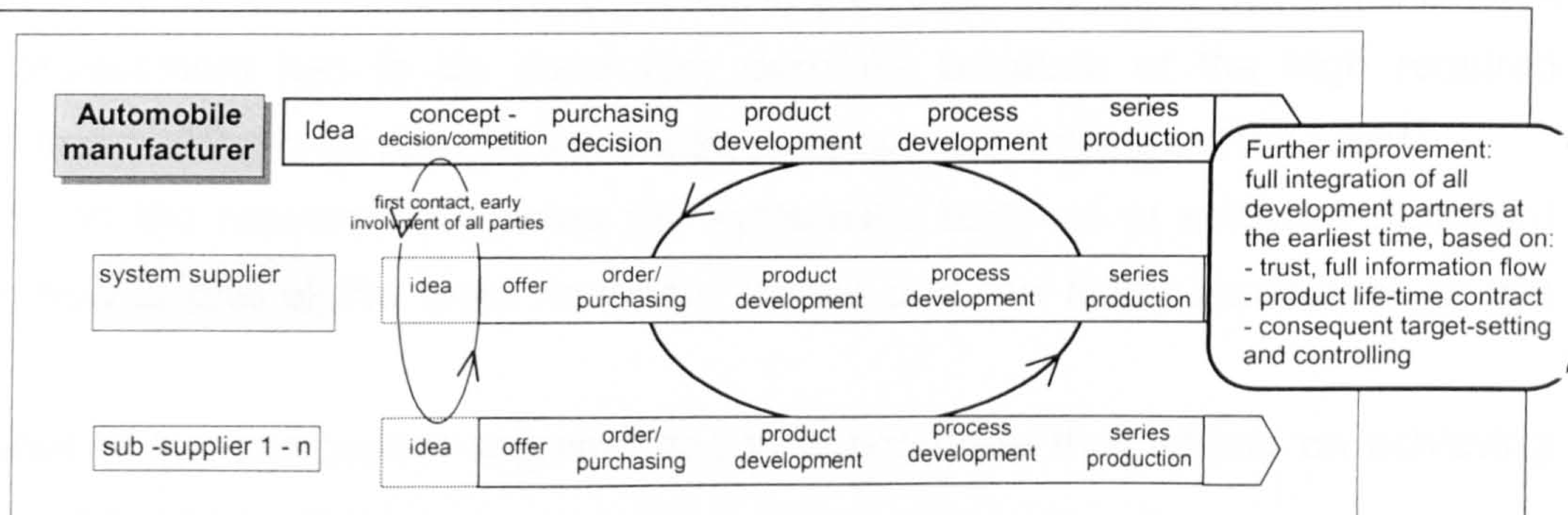
Figure 9.6: Factors involved in improving efficiency of the development process

Based on priority, the model is predominantly dictated by the main prerequisites for a more efficient development process (see Chapter Eight) that were analysed. The model clearly indicates a focus on the formation of an Inter-Co-operational Supplier Structure, "ICOSS". The investigation showed that involvement of all parties - internal and external - as early as possible in order to achieve optimised results is of utmost importance (Figure 9.7). Efficient, targeted tools have been able to secure professional internal and external flow of information between all parties. Furthermore, they have ensured a maximum of system flexibility, compatibility and simple application among the development parties to eliminate possible bottlenecks within the development process. Compared to the current models, sequential introduction of the supplier (Figure 8.8) and system supplier oriented model (Figure 8.9), the Inter-Co-operational Supplier Structure “ICOSS”, offers all parties a option for gaining all necessary inputs at the earliest time possible in the development process where the basis for later success of product success is defined. The significance of the foundations that initial development activities were based on was another important factor identified. Development must begin with clear specifications and agreements. This differs from the analysis according to which over 50% of development activities start with verbal agreements, a description or abstract specifications. Clear specifications and development launches based on personal meetings/arrangements are thought to have great potential for improvement. A good method would be to start development activities on the basis of a joint "workshop" - OEM, supplier, sub-supplier, - at which all relevant peripheral conditions are discussed clearly and openly. This would be especially useful in view of the fact that most occurrences of delay and unnecessary expenditure are caused by information that is incomplete or has not passed on. An RCI-matrix (responsibility, co-operation, information) should be defined for all relevant subjects at the beginning so that everybody is familiar with the details of their role and what they will be expected to do.

Significant potential for making the development process more efficient is also seen in meeting deadlines on the part of manufacturers and sub-suppliers and compliance with agreements made.

A requirement for an efficient development process is also a central project team location in order to ensure a quick exchange of information and short decision-making processes as well as the appropriate allocation of authority to the project managers which seems currently not to be in proportion to their responsibility (installing heavyweight project manager[223]).

Another factor is the little support from the sub-supplier compared to those given to the customer. Therefore, improvements can be realised by pushing the external sub-suppliers to improve their support services and use it in a more efficient way (through concept competition, invite them more frequently for presentations, resident engineer for the concept phase).



	Advantages	Disadvantages	Remarks
"ICOSS" Inter-co-operational supply structure	- less waste of time through early involvement of all suppliers - very quick decision-making process → reduction of lead time and productivity increase - best solution can be offered initially through efficient information flow & management	- dependency of the OEMs on suppliers due to early involvement and full information flow - know-how loss to supplier - compatible tools are required along the supply chain	- early involvement of all parties required - full information flow, trust and reliability are absolutely necessary pre-conditions - appropriate contracts will regulate the usage of know-how and information flow between the parties - ICOSS parties must define: • responsibilities • interfaces • change management • information/material flow

Figure 9.7: Development model (Inter co-operational supply structure)

[223] Concerning Fujimoto: "The heavy weight product manager maintain a strong influence not only in engineering organisations, but also in production and marketing. They are not only engineering co-ordinators but also product planners and concept champions. In addition,

9.3 Strategic aspects of automotive suppliers' future planning

Several important strategic factors that may be very useful to companies when it comes to the formulation of strategy and the definition of the portfolio constellation have been identified. The task of the strategy evaluation and selection is to compare the alternative strategic possibilities and to select finally one, which will be implemented. For that, strategic relevant information is the basis for doing this.

First of all the list of the ranked requirements for the different supplier levels gives valuable information about the existing gaps and necessary organisational adaptation. A good estimation about the grade of changes and investment can be conducted with reference to the strategic goals.

The analyses also gives detailed information about intelligently supplementing (buying-in, JV, co-operations) competence in the field of mechanics and electronics so that system suppliers can present themselves single-mindedly and successfully as such.

Depending on the size of the company, the results indicate the need of formation of strategic partnerships with OEMs or with other suppliers in order to counteract the reduction in suppliers. Becoming actively involved in the development process of OEMs as early as possible by performing specific preliminary work in selected areas could be another method to reinforce the relation to the customer. Rational risk assessment has to be done very carefully because of the high required investment taking over specific advanced development tasks from the OEM.

Based on the research outcomes the systematic build-up of software (function) know-how is one of the most important issues due the rising importance of this topic.

Supplier of the component segment has to concentrate their efforts on achieving cost leadership position.

Despite certain advantages, becoming a system supplier is not always the most sensible choice due to the high requirements, high risks, high investment and preliminary work it is sometimes economically much more interesting for component suppliers to attain cost leadership in their segment than to develop into a system supplier. The fact that the OEMs still have direct contact with the sub-system and component supplier must be carefully considered. The pyramidal supplier structure where only the system supplier is co-ordinating the

they maintain the direct contact to the customer", in: Fujimoto, T., Organisation for effective product development, PhD thesis, Harvard Business School, 1998, pp. 456, 458a development-/supply chain will not be fully realised. This could lead to a situation where the system supplier is fully responsible for the co-ordination and the success of a product development but has not the total control of the process.

Chapter Ten: Conclusion

For over two decades, the automotive industry has been in a phase of change which was mainly driven by the outcomes of the world-wide automotive research program titled "International motor vehicle program" and conducted under the leadership of the Massachusetts Institute of Technology (MIT) in the early '80s. This study indicated clearly the strengths and weaknesses of the automotive situation within the main regions of NA and Western Europe compared to the situation in Japan. The results have lead to significant internal and external changes and structural, process and strategic adaptation in NA and Western Europe automotive companies in an effort to catch up with the Japanese companies.

Continued increase in the complexity, dynamics and competitiveness of business driven by more stringent requirements in terms of safety, comfort and the environment along with growing globalisation are still subjecting the automotive industry to remarkable upheaval. This situation becomes evident when we consider the number of world-wide mergers, joint ventures and co-operations among OEMs and suppliers accompanied by adaptive changes in OEMs' depth of manufacturing, development and core competencies. Product integration and the creation of so-called systems, sub-systems and components have been defined as a valuable instrument for overcoming market constraints. These have consequently led to a change in supplier structures, supplier requirements and the relationship between OEMs and suppliers.

The purpose of the research work was to enhance understanding of the system-building strategy of the European OEMs, the requirements OEMs expect from the various supplier levels (system, sub-system, components), the main changes within the OEM–supplier relationship and the main prerequisites for a more efficient development process involving OEMs and suppliers. The research project was based on an empirical investigation. It was conducted at a European automobile manufacturer's and a major automotive supplier's.
Based on the investigated results, an attempt has been made to develop two things: Firstly, to develop an optimised organisational model for automobile supplier with the necessary grades of requirements for each supplier level;

secondly, to develop a more efficient development process model for co-operation between both parties, OEM and supplier, as well as the rules for this optimised development process. The aim was to close the existing gap in research within the relevant scientific field and to deliver valuable information for future activities and research projects.

This research was the result of a co-operative research project at the Department of Engineering and Information Sciences of the University of Hertfordshire and Siemens Automotive.

A comprehensive review of the literature was undertaken as a point of departure for the research paper (Chapter Two). The existing literature proved to be somewhat limited with reference to the specific field of research. The insights gained from the reports and scientific articles studied are either restricted in terms of scope or only partially cover the relevant aspects.

Chapters Three and Four present further basic information for the research paper. Chapter Three presents the objectives of the research work and defines the conceptual framework along with the procedure for achieving the goals. Chapter Four provides a general overview of the automotive industry, the individual phases in the automobile industry and the impact prerequisites for current and future changes.

Chapter Five deals specifically with product integration. It discusses the driving forces behind product integration and the building of so-called systems and presents some examples of product integration and the opportunities and risks for the OEM and supplier resulting from product integration.

The empirical investigation came up with very interesting results and valuable contributions to the existing knowledge base. Finding out whether there is a trend toward standardisation of OEMs' system building strategies or whether OEMs are using different approaches constituted the first goal (Chapter Six).

Analysis of the data did not reveal any major trend toward standardisation in terms of system building – product segmentation scenario, - which was viewed an important indicator for the companies' organisation. Neither did it identify any clear line of product classification in general. The individual automobile manufacturers are each going their own way! The units, seat, dashboard, wiring, engine and transmission were the only ones to be classified clearly as systems, and the electronic units (engine management, transmission control, navigation, seat control) were mainly classified as systems or sub-systems. This means that the supplier industry must adjust itself to highly diverse constellations of product content and corresponding requirements.

The analysis indicated that OEMs have clearly expressed different requirements for system, sub-system and component suppliers (Chapter Seven). The challenging requirements applying to system suppliers relate to innovative power, development competence and capacity, logistics know-how and advance investments. The requirements for the system supplier those for the sub-system supplier has been ranked very high compared to the system supplier with reference to "delegating manpower to the OEM" and "providing support by marketing new products/technologies". This would mean that a sub-system supplier can become a system supplier with relative little effort and low investment. The component supplier ranking was far lower relative to the other levels. Accordingly, comparatively more effort and investment are required to advance to the next level. This applies with reference to one issue, namely "cost pressure", for all of the topics investigated. Here, the greatest demands are placed on the component supplier.

The third part, the investigation of the changing relationship between customer and supplier in general and the main prerequisites for a more efficient development process yielded very interesting findings. It was found that the supplier volume will continue to decrease. OEMs will reduce their supplier base by 1/3 of the current volume on average, which confirms existing information found in the literature. OEMs believe that this reduction will produce improvements of 20-60% on average with regard to time-to-market, reaction time, quality, cost reduction, innovation rate, etc.. The results also shoed a trend toward fewer, but larger "system suppliers", although there was scepticism of any supplier being too powerful (mega supplier). OEMs will maintain contacts with sub-system and component suppliers, to the effect that there will not be any systematic implementation of a pyramid-shaped structure of suppliers, where system suppliers are responsible for co-ordinating sub-suppliers. Beyond that, electronics suppliers are taking on more and more (system) responsibility, thereby eliminating the dominance of mechanical suppliers. System suppliers will need to be competent in both fields, mechanics and electronics.

It was interesting to find that available software know-how will be a decisive factor in the future. The level of software development and requirements will set the standards in hardware.

It is not enough for system suppliers to restrict themselves to production and process know-how with reference to OEMs. Extensive product know-how is needed to qualify as a system supplier.

OEMs also intend to integrate suppliers into the development process earlier and more intensively. This will not be limited to system suppliers and there was not a clear statement by the OEMs that they will only have direct contact with the system suppliers who are responsible for integrating the sub-system and component suppliers into the development process. Nonetheless, there was still thought to be a relatively high risk of dependency, which is counterproductive.

The following major prerequisites for a more efficient development process were identified (Chapter Eight). Meeting deadlines on the part of manufacturers and sub-suppliers and adherence to agreements constituted one of the major issues. Further major prerequisites included initiation of the development process on the basis of clear specifications and agreements (e.g. by having a joint workshop at the onset of the development process) and optimised internal and external flow of information, requiring tool compatibility, central location of the project team members and earlier integration of all parties. Vesting of the necessary authority (technical and economical) in the project manager (installing a heavy weight project manager) was also considered an important prerequisite. This would ensure a short decision-making process and enable more support from the sub-suppliers, a factor that has obviously been neglected until now.

All of the factors investigated represent the necessary basis for the primary goal, namely to develop an optimised organisational model for automotive suppliers and a more efficient development process with reference to co-operation between the OEM and its suppliers, which are presented in Chapter Nine.

In summary, this research paper makes a valuable contribution to the existing knowledge base and reduces the verified gap within the relevant research. The results may be very useful to individual suppliers in determining their internal organisational structure, the conditions of the development process and interaction of OEMs and suppliers. They may also prove very useful for the allocation of resources and in making strategic decisions in respect of necessary alliances and co-operations.

Nevertheless, the relevant scientific field still offers a wide range of potential for future research.
An initial opportunity would be based on the results evaluated and models developed in the study at hand, such as:

- a derivation of prognoses
- a translation of these prognoses into situation-specific instructions for activities
- followed by attempts at empirical realisation
- and finally, a verification of the temporary acceptance theory in order to conclude the research process[224].

Due to the fact that the research activities were limited to the European Market, it would be interesting to carry out the investigation in the NA and Japan regions. This would also present another valuable opportunity for future research activities

It would also be interesting to carry out an investigation of the "main prerequisites for a more efficient relationship - OEM and supplier - with a focus on the development process" at another automotive supplier's besides Siemens Automotive.

[224] See Hill,W./Fehlbaum,R./Ulrich,P., Organisationslehre 1, 5th edition, Paul Haupt publishing, Bern, Stuttgart, Wien, 1994, p. 39

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Appendix A:

External Questionnaire

To investigate:

- OEMs' system-building standardisation trends
- The specific requirements of each individual supplier level and
- Changes in the future automobile manufacturer-supplier relationship

A) General trends

■ ***Supplier situation and trends!***

1) How many <u>direct</u> suppliers do you currently have?

Current number:...................
Future target: ....

2) Which statement is true in your opinion?

	Yes (1)	No (2)	No statement (3)
● A reduction in the number of direct suppliers is an ongoing process.	❑	❑	❑
● There is a trend toward bigger and fewer major system suppliers.	❑	❑	❑
● In the long run, we will only deal with and conduct our purchasing activities with major system suppliers (< 50 major system suppliers) .	❑	❑	❑
● The trend toward bigger and fewer major system suppliers will be favourable for the automobile industry.	❑	❑	❑
● The trend toward bigger and fewer major system suppliers will be critical for the automobile industry.	❑	❑	❑
● Because of their advantages in terms of flexibility & reaction time etc., we will still prefer to use small-sized and medium-sized suppliers in some cases	❑	❑	❑

3) If you intend to reduce your number of suppliers and rely on fewer suppliers *(if not, please omit this question!)*, what are your expectations with reference to the following factors?

	Factor of improvement in %					
	0% (1)	20 (2)	40 (3)	60 (4)	80 (5)	100% (6)
Cost reduction	❑	❑	❑	❑	❑	❑
Time to-market will improve	❑	❑	❑	❑	❑	❑
Reduction of co-ordination efforts	❑	❑	❑	❑	❑	❑
Reaction time (market requirements)	❑	❑	❑	❑	❑	❑
The rate of innovation will improve	❑	❑	❑	❑	❑	❑
Improvements in quality	❑	❑	❑	❑	❑	❑
Others:..	❑	❑	❑	❑	❑	❑

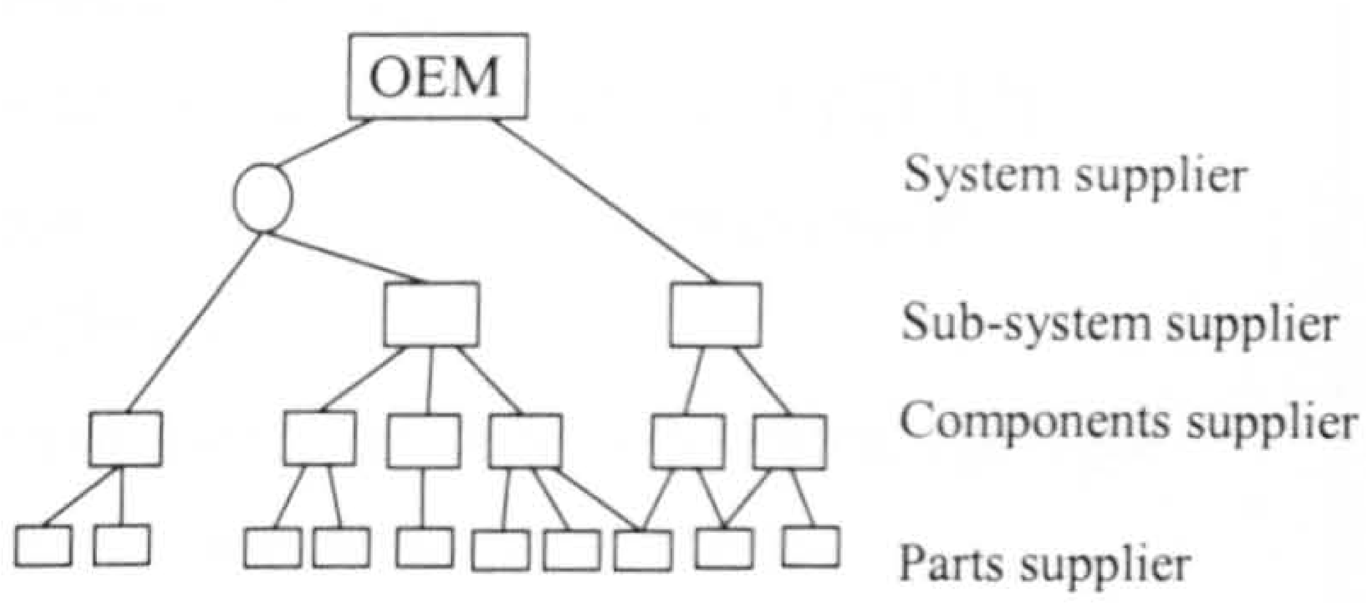
B) Future product segmentation scenario

The main intent of the following questions is to analyse the future preferred supplier structure and to investigate the product segmentation scenario in detail.
Restructuring of the supply chain is an issue presently being discussed intensively, but no clear picture has emerged to date.
Therefore, the research study attempts to analyse in detail what future product allocation will look like with reference to system, sub-system and components.
Is there an identifiable common orientation?

1) What kind of supplier structure will we have you the future?

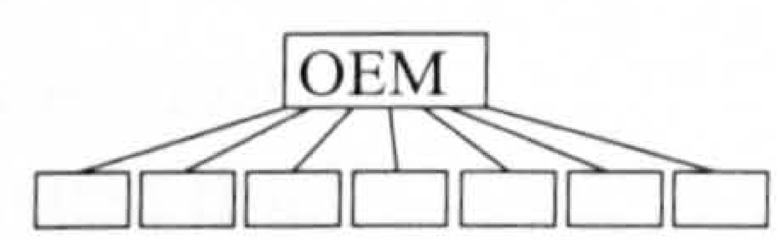
a) Pyramidal-shaped supplier structure

Yes ❑ (1) No ❑ *(If yes, go to 2)*



b) Conventional horizontal supplier structure

Yes ❑ (2) No ❑ *(If yes, go to 3)*



c) We have a different supplier structure. Yes ❑ (3) No ❑ *(If yes, go to 4)*

Characteristics of this structure - important comments and advantages?

Sketch:

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2) If **1a) pyramidal supplier structure applies:**

What will your future product classification look like? What do you define as a system, sub-system and component? Please indicate each product according to your classification as described:

* Please indicate systems by entering * Please indicate sub-systems by entering * Please indicate components by entering * If no classification fits, please enter	"S" "SS" "C" "N"	(1) (2) (3) (4) "Please indicate systems by entering" * Please indicate sub-systems by entering * Please indicate Components by entering * If no classification fits, please enter	"S" "SS" "C" "N"	(1) (2) (3) (4)
e.g. Item 1 steering wheel	....C...	* suspension	....	
		* seat electronics (heating, memory).	....	
* engine	....	* door interior	....	
* engine parts (crank, shaft, piston etc.)	....	* dashboard	....	
* injection system	....	* interior (floor, ceiling)	....	
* engine management	....	* instruments	....	
* diesel injection, electronically controlled	....	* navigation	....	
* intake air system	....	* heating system, climate control	....	
* exhaust system	....	* airbag, side airbag	....	
* transmission	....	* body parts	....	
* transmission control unit (TCU)	....	* bumper (front, rear)	....	
* automatic clutch management	....	* lighting system front	....	
* differential	....	* lighting system rear	....	
* axle parts, shock absorbers, springs	....	* windows	....	
* active suspension system	....	* wiring system, multiplexing	....	
* braking system	....	* electric/electronic engine systems		
* steering system	....	(elect. windows, windscreen wiper etc.)	....	
* seats (front, rear)	....	* locking system	....	
* starter, generator, other items not listed:	....	* immobilisation	....	
....	....			
....	....	....	....	
....	....	....	....	
....	....	....	....	
		....	....	

3) If **1b) Conventional horizontal supplier structure applies:**

Do you differentiate between the suppliers (e.g. high volume supplier, preferred supplier etc.)?

Yes ❑ (1) No ❑ (2)

If yes, please explain briefly your:

Supplier differentiation:..

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....

Possible product classification:...

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4) If **1c) Another supplier structure applies:**

Please describe your product classification system.

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C) Characteristics of the individual segments

We can assume that car manufacturer' requirements/expectations differ from those of their suppliers (system, sub-system, components).
This section will attempt to analyse the specific requirements for the different supplier levels.

In your view, which factors are characteristic of or form a requirement for a supplier belonging to one of the given levels?

Please use the tables below if you have a <u>conventional horizontal</u> supplier structure (Point B1b) or <u>a structure</u> that is not a pyramidal-shaped supplier structure(Point B1c),.
Use the columns, "Supplier 1, Supplier 2 or Supplier 3", depending on your supplier structure. If you don't differentiate between your suppliers, use the column, "Supplier 1".

Characteristic factors	Expected requirements for **System, sub-system, component suppliers** **Or** (Supplier 1, 2 or 3 depending on your structure)

* **Development capability**	Capability for developing new systems/products/ functions <u>autonomously</u>	Limited capability, development activities commonly with the OEM	No capability for carrying out development tasks
system supplier (Supplier 1)	❑ (1)	❑ (2)	❑ (3)
sub-system supplier (Supplier 2)	❑ (1)	❑ (2)	❑ (3)
components supplier (Supplier 3)	❑ (1)	❑ (2)	❑ (3)

* **Rate of innovation**	low					high	not relevant
system supplier (Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦
* **Mechanical know-how**	low					high	not relevant
system supplier(Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier(Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦
* **Electric/electronic know-how**	low					high	not relevant
system supplier(Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier(Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦
* **Software know-how**	low					high	not relevant
system supplier (Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦
* **Production/process know-how**	low					high	not relevant
system supplier(Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier(Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦
* **Reaction time (market**	low					high	not relevant
requirements) *system supplier (Sup 1)*	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** Cost pressure**	low					high	not relevant
system supplier (Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier(Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** R & D resources**	vast R & D resources, centres	partly own R & D	very limited R & D resources	no R&D resources, built to print
system supplier (Supplier 1)	☐ (1)	☐ (2)	☐ (3)	☐ (4)
sub-system supplier (Supplier 2)	☐ (1)	☐ (2)	☐ (3)	☐ (4)
components supplier (Supplier 3)	☐ (1)	☐ (2)	☐ (3)	☐ (4)

*** Quality management**	low					high	not relevant
system supplier(Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** Testing/qualification know-how**	not required	Required to a moderate degree	absolutely necessary	not relevant
system supplier (Supplier 1)	☐ (1)	☐ (2)	☐ (3)	☐ (4)
sub-system supplier(Supplier 2)	☐ (1)	☐ (2)	☐ (3)	☐ (4)
components supplier(Supplier 3)	☐ (1)	☐ (2)	☐ (3)	☐ (4)

*** Logistic capabilities (e.g. JIT), delivery flexibility**	low					high	not relevant
system supplier	①	②	③	④	⑤	⑥	⑦
sub-system supplier	①	②	③	④	⑤	⑥	⑦
components supplier	①	②	③	④	⑤	⑥	⑦

*** Support from the marketing of new products/technologies**	low					high	not relevant
system supplier (Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** Global presence (manufacturing, development, service)**	low					high	not relevant
system supplier (Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier(Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** Broad product spectrum**	low					high	not relevant
system supplier(Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier(Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** Investment capacity (facilities, tools etc.)**	low (< 1m $)	(1 – 10m $)	(10-50m $)	high (> 50m $)	Other:
system supplier(Supplier 1)	☐ (1)	☐ (2)	☐ (3)	☐ (4)	.... Million $
sub-system supplier (Supplier 2)	☐ (1)	☐ (2)	☐ (3)	☐ (4)	.... Million $
components supplier(Supplier 3)	☐ (1)	☐ (2)	☐ (3)	☐ (4)	.... Million $

*** Supplier sales volume**	> 5bn $	3 – 5bn$	1 – 3bn$	0,5-1bn $	0.1–0.5bn $	< 0.1bn$
system supplier (Supplier 1)	☐ (1)	☐ (2)	☐ (3)	☐ (4)	☐ (5)	☐ (6)
sub-system supplier(Supplier 2)	☐ (1)	☐ (2)	☐ (3)	☐ (4)	☐ (5)	☐ (6)
components supplier (Supplier 3)	☐ (1)	☐ (2)	☐ (3)	☐ (4)	☐ (5)	☐ (6)

*** Delegating manpower to OEM (limited period of time)**	low					high	not relevant
system supplier (Supplier 1)	①	②	③	④	⑤	⑥	⑦
sub-system supplier (Supplier 2)	①	②	③	④	⑤	⑥	⑦
components supplier (Supplier 3)	①	②	③	④	⑤	⑥	⑦

*** Average duration of contract with the supplier.**	< 1 year	1 - 3 years	product life time	no contract
system supplier (Suppl. 1)	☐ (1)	☐ (2)	☐ (3)	☐ (4)
sub-system supplier(Supplier 2)	☐ (1)	☐ (2)	☐ (3)	☐ (4)
components supplier (Supplier 3)	☐ (1)	☐ (2)	☐ (3)	☐ (4)

D) Supplier Relationship and Definitions

1) How would you rank the future intensity of your supplier relationship?

	System supplier or Supplier 1	Sub-system supplier or Supplier 2, depending on your structure	Component supplier or Supplier 3, depending on your structure
	low high	low high	low high
General intensity of the relationship	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
Intensity of the relationship with reference to:	low high	low high	low high
* Car concept, styling	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Product planning	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Product development	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Qualific./application/testing	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥

2) How would you rank the following factors with reference to a closer relationship (earlier involvement of the supplier in the development process) and more intensive flow of information to the supplier?

	System supplier (Supplier 1)	Sub-system supplier (Supplier 2)	Component supplier (Supplier 3)
	low high	Low	low high
* Fear of supplier dependency	① ② ③ ④ ⑤ ⑥	high	① ② ③ ④ ⑤ ⑥
* Loss of product know-how	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Loss of process know-how	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Possibility of cost reduction	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Reduction of development time	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Increasing own competitiveness	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Reduction of failure	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Utilisation of synergy effects	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
Other factors:		① ② ③ ④ ⑤ ⑥	
....	① ② ③ ④ ⑤ ⑥		① ② ③ ④ ⑤ ⑥
....	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
		① ② ③ ④ ⑤ ⑥	

3) From your perspective, which statement(s) is/are true?

	Yes (1)	No (2)	No statement (3)
A) The definitions of "system" and "sub-system" always depends on the vehicle concept and the definition of the interfaces.	❑	❑	❑
B) It is not mandatory for the system supplier to have detailed product know-how.	❑	❑	❑
C) The main task of the system supplier is to combine the sub-systems and Components into one unit and deliver the unit JIT to the OEM.	❑	❑	❑
D) Only the system supplier will be involved in the product development process intensively and at an early stage. The system supplier will be responsible for integrating the sub-system/component supplier into the development process.	❑	❑	❑
E) We will have close and direct contact with all supplier levels, although we will reduce the overall number of contacts!	❑	❑	❑

4) With respect to the increasing share of electronics in the vehicle's, which statement(s) do you feel is/are true?

	Yes (1)	No (2)	No statement (3)
A) Although the content managed by electronics suppliers is constantly rising, the mechanics suppliers will still hold overall responsibility. The electronics suppliers are the sub-system supplier or component supplier.	❑	❑	❑
B) The designer of the electronic (control unit) will assume more and More responsibility due to the rising importance of electronic Hard- and software.	❑	❑	❑
C) In the long run, the electronic designer will assume the entire responsibility.	❑	❑	❑
D) A system supplier must have a knowledge of both mechanic and electronic (hardware and software).	❑	❑	❑
E) A knowledge of software (system function etc.) will be the key issue for the future.	❑	❑	❑

5) How would you rank the future importance of the mechanic, electronic and software with respect to the system/product responsibility for the items listed?

Items \ Importance of	Mechanic	Electronic	Software
	low high	low high	low high
* Engine management	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Diesel injection, electronic controlled	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Automatic transmission	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Automatic clutch management	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Braking system (ABS)	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Passenger restrain systems (airbag)	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Traction control	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Climatic system	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Navigation	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Infrared/radio controlled locking system	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Instruments, displays	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Electronic power steering	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Active cruise control	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥
* Brake by wire	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥	① ② ③ ④ ⑤ ⑥

6) What products would <u>you never</u> outsource for reasons of core-competence and/or marketing aspects?

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Appendix B:

Internal Questionnaire

To investigate the main factors for a more efficient development value chain against a background of increasing product integration and complexity and decreasing development time and cost.

1. Please describe your current business relations with your customer (e.g.OEM)! How does it act concerning the following aspects?

		outstanding	very good	good	satisfactory	weak	unsatisfactory	importance *)
Early supplier involvement in future development projects?		O	O	O	O	O	O	
Trust		O	O	O	O	O	O	
Willingness to compromise	made commitments	O	O	O	O	O	O	
	milestone settings	O	O	O	O	O	O	
Easy to contact		O	O	O	O	O	O	
Equal partnership		O	O	O	O	O	O	
Interface defintion		O	O	O	O	O	O	
Intention of a long-term relationship		O	O	O	O	O	O	

*) 4 = very imortant 3 = important 2 = not so important 1 = not important

2. Please describe your current business relations with your supplier.

		outstanding	very good	good	satisfactory	weak	unsatisfactory	importance *)
Early supplier involvement in future development projects		O	O	O	O	O	O	
Trust		O	O	O	O	O	O	
Willingness to compromise	made commitments	O	O	O	O	O	O	
	milestone settings	O	O	O	O	O	O	
Easy to contact		O	O	O	O	O	O	
Equal partnership		O	O	O	O	O	O	
Interface defintion		O	O	O	O	O	O	
Intention of a long-term relationship		O	O	O	O	O	O	

*) 4 = very imortant 3 = important 2 = not so important 1 = not important

3. How did your customer implement the following elements? Please evaluate!

		outstanding	very good	good	satisfactory	weak	unsatisfactory	importance *)
Simultaneous engineering		O	O	O	O	O	O	
Quick decision-making process		O	O	O	O	O	O	
Intercooperational teamwork		O	O	O	O	O	O	

*) 4 = very imortant 3 = important 2 = not so important 1 = not important

4. a) Please indicate how information exchange between the customer and the supplier is currently handled.	percentage of each aspect [%]	b) Please indicate the efficiency of each aspect, bearing in mind that product integration/complexity will increase and development times/costs will have to be reduced in the future.					
		outstanding	very good	good	satisfactory	weak	unsatisfactory
Personal agreements/meetings		O	O	O	O	O	O
Video conferences		O	O	O	O	O	O
Telephone/fax		O	O	O	O	O	O
E-mail/EDI (electronic data interchange)		O	O	O	O	O	O

5. b) Development activities start on the basis of......	percentage of each aspect [%]	b) Please indicate the efficiency of each aspect, bearing in mind that product integration/complexity will increase and development times/costs will have to be reduced in the future.					
		outstanding	very good	good	satisfactory	weak	unsatisfactory
verbal agreements/description.		O	O	O	O	O	O
design specifications in form of a detailed technical and functional description.		O	O	O	O	O	O
design specifications in form of a detailed technical and functional description.		O	O	O	O	O	O
workshops together with OEM`s specialists.		O	O	O	O	O	O
workshops together with OEM`s specialists and the most important development partners/sub-suppliers.		O	O	O	O	O	O

6. a) Please evaluate the current usage of standardised tools and methods in project management and information management during the development process!

b) Importance for meeting future requirements?

c) Possible actions for improvements? Please give your suggestions!

		outstanding	very good	good	satis-factory	weak	unsatis-factory	very important	important	not so important	not important	
6 I.	Reviews	O	O	O	O	O	O	O	O	O	O	
	Resource planning tools	O	O	O	O	O	O	O	O	O	O	
	Budget planning tools	O	O	O	O	O	O	O	O	O	O	
	Cost control tools	O	O	O	O	O	O	O	O	O	O	
	Schedule/milestone control tools	O	O	O	O	O	O	O	O	O	O	
	Component reliability prognosis	O	O	O	O	O	O	O	O	O	O	
	Design/process FMEA	O	O	O	O	O	O	O	O	O	O	
	Technical calculation tools	O	O	O	O	O	O	O	O	O	O	
	Intuitive/heuristic mehtods	O	O	O	O	O	O	O	O	O	O	

			outstanding	very good	good	satis-factory	weak	unsatis-factory	very important	important	not so important	not important	
6 II.	Develpment /design tools for....	mechanical parts	O	O	O	O	O	O	O	O	O	O	
		hardware	O	O	O	O	O	O	O	O	O	O	
		software	O	O	O	O	O	O	O	O	O	O	
		functions	O	O	O	O	O	O	O	O	O	O	
6 III.	Simulation tools for....	mechanical parts	O	O	O	O	O	O	O	O	O	O	
		hardware	O	O	O	O	O	O	O	O	O	O	
		software	O	O	O	O	O	O	O	O	O	O	
		functions	O	O	O	O	O	O	O	O	O	O	
6 IV.	Data bases / virtual libraries for getting easy access to ...	technical terms of delivery	O	O	O	O	O	O	O	O	O	O	
		CAD-drafts of existing products	O	O	O	O	O	O	O	O	O	O	
		status of component availability	O	O	O	O	O	O	O	O	O	O	

7. **a) Please evaluate the general situation inside the projects regarding ....!**

									b) Importance for meeting future requirements?				**c) Possible actions for improvements? Please give your suggestions!**
			outstanding	very good	good	satis-factory	weak	unsatis-factory	very important	important	not so important	not important	
7 I.	internal information flow (in general)		O	O	O	O	O	O	☐	☐	☐	☐	
	(in detail)	internal data network	O	O	O	O	O	O	☐	☐	☐	☐	
		system compatibility between locations/ departments, e.g. CAx	O	O	O	O	O	O	☐	☐	☐	☐	
	external information flow to the customer (in general)		O	O	O	O	O	O	☐	☐	☐	☐	
	(in detail)	external data network to the customer	O	O	O	O	O	O	☐	☐	☐	☐	
		system compatibility to the customer, e.g. Cax	O	O	O	O	O	O	☐	☐	☐	☐	
	external information flow to the supplier (in general)		O	O	O	O	O	O	☐	☐	☐	☐	
	(in detail)	external data network to the supplier	O	O	O	O	O	O	☐	☐	☐	☐	
		system compatibility to the supplier, e.g. Cax	O	O	O	O	O	O	☐	☐	☐	☐	
7 II.	support to the customer, e.g. resident engineers if desired		O	O	O	O	O	O	☐	☐	☐	☐	
	support from the supplier regarding...	concept definition	O	O	O	O	O	O	☐	☐	☐	☐	
		technology											
		qualification	O	O	O	O	O	O	☐	☐	☐	☐	
7 III.	usage of common component concept		O	O	O	O	O	O	☐	☐	☐	☐	
	support from the supplier regarding...	mechanical design	O	O	O	O	O	O	☐	☐	☐	☐	
		hardware											
		software	O	O	O	O	O	O	☐	☐	☐	☐	

8. **Please, specify the percentage of the following aspects for each development phase based on your project experiences!**

Development phase	Average R&D spendings per phase [%]	Cost relevant decisions per phase {%]	Specification changes by customer per phase [%]	Delays generated by the supplier per phase [%]
Customer request				
Project start				
Concept release				
Specification b-sample				
Specification c-sample				
Function release				
Product release				
Manufacturing release				
After SOP				
total	100%	100%	100%	100%